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Intertidal Clam Resources on the West Coast of Vancouver Island: Surveys of Intertidal Clam Stocks on the West Coast of Vancouver Island in Areas 23 to 25 - 1981 to 1987

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INTERTIDAL CLAM RESOURCES ON THE WEST COAST OF VANCOUVER ISLAND: SURVEYS OF INTERTIDAL CLAM STOCKS ON THE WEST COAST OF VANCOUVER ISLAND IN AREAS 23 TO 25 - 1981 TO 1987

by:

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Adkins, B. E. and R. M. Harbo. 1991. Intertidal clam resources on the West Coast of Vancouver Island: Surveys of intertidal clam stocks on the West Coast of Vancouver Island in Areas 23 to 25, 1981 to 1987. Can. Manuscr. Rep. Fish Aquat. Sci. 2070: 89 p.

ABSTRACT

The commercial intertidal clam fishery on the West Coast of Vancouver Island is unique in its history of harvesting and the remoteness of many of the small isolated clam beaches. Since the early 1980's commercial landings of native littleneck and manila clams have been at record levels and this has raised concerns of over-harvesting and stock depletion in many west coast areas.

During the period of 1981 to 1987 twenty commercial clam beaches on the West Coast of Vancouver Island were surveyed to examine stock composition and abundance and monitor relative changes over time in relation to an escalation in effort and landings in the commercial intertidal clam fishery. Several of these beaches were surveyed periodically or annually while others were surveyed only once. Mean densities and length frequency distributions for native littleneck manila and butter clams are presented for each survey at each location.

Mean densities of legal and sublegal size clams were variable between beaches. At most locations density of legal size native littleneck and manila clams declined over time while recruitment of sublegal size clams fluctuated over time. At all locations, the lowest densities of legal and sublegal size clams were recorded on the last survey.

Management concerns are presented and some recommendations for future management of the west coast commercial intertidal clam fishery are made.

Key words: Clams, surveys, management, West Coast of Vancouver Island.

RÉSUMÉ

Adkins, B. E. et R. M. Harbo. 1990. Evaluation des stocks de clams intertidaux sur la côte ouest de l'Isle Vancouver dans les zones 23 à 25, de 1981 à 1987. Rapp. manuscr. can. sci. halieut. aquat., 2070 : 89 p.

La récolte commerciale des clams sur la côte ouest de Isle Vancouver est unique sur le plan historique et en ceci que bien des petites plages isolées ou elle s'affectue sont situées dans des régions éloignées. Depuis le début des années 1980, les débarquements commerciaux de quahaugs communes indigénes et d'asaris ont atteint des quantités record qui ont fait craindre que les stocks soient surexploités et décroissent dans beaucoup de régions de la côte ouest.

De 1981 à 1987, nous avons effectué une campagne d'échantillonnage portant sur vingt plages où se fait la récolte commercials des clams sur la côte ouest de l'Isle Vancouver. Cette campagne visait â établir la composition et l'abondance des stocks de clams de meme que l'évolution de ces stocks dans le temps en regard de l'accroissement de l'effort de récolte et des débarquements commerciaux de clams. Plusieurs de ces plages ont fait l'objet d'échantillonnages périodiques ou annuels tandis que d'autres n'ont été visitées qu'une fois durant cette période. Pour chacun des échantillonnages effectués sur chacune des plages, nous présentons les densités moyennes et les distributions selon la longueur des parlourdes jaunes, des quahaugs communes indigenes et des asauis.

Les densités moyennes des clams de taille légale ou de taille inférieure aux normes de commercialisation étaient variables selon les plages. Sur la plupart des plages, la densité des quahaugs communes indigénes et des asaris de taille légale diminuait avac le temps tandis que le recrutement des clams de taille inférieure fluctuait. Partout, les densités les plus basses de clams de tailles légale et inférieure ont été observées au dernier echantillonnage.

Nous traitons des problémes relatifs à la gention de la récolte commerciale des clams sur la côte ouest et présentons certaines recommendations.

Mots Clés: clams, campagnes d'echantillonnage, gestion, côte ouest de l'Isle Vancouver.

INTRODUCTION

WEST COAST CLAM FISHERY

Commercial intertidal clam beaches are scattered along many of the coastal inlets on the west coast of Vancouver Island. Unlike commercial clam beaches on the east coast of Vancouver Island they are typically small, have limited intertidal areas and many have oceanic rather than estuarine water conditions. Most west coast clam beaches are located in remote areas, often considerable distances from road access, permanent habitation and markets.

The west coast of Vancouver Island, Pacific Fisheries Management Areas 23 to 27, (Fig. 1) supports commercial fisheries for three species of intertidal clams; butter (Saxidomus giganteus), littleneck (Protothaca staminea) and manila (Tapes philippinarum). These species are harvested by hand digging with forks or rakes, although mechanical harvesters were used in some areas periodically between 1964 and 1982 (Bourne, 1986; Adkins et al. 1983).

Total reported landings of intertidal clams from the west coast of Vancouver Island have fluctuated widely since collection of clam statistics began in 1951 and have ranged from a low of 2.6 tonnes in 1953 to 730 tonnes in 1987 (Table 1). This represents a range of from less than 1% to 22% of the total British Columbia clam landings for all three commercial species (Table 2). Since the early 1980's commercial clam landings in British Columbia have increased sharply and have been at record levels since 1983. Clam landings from the west coast of Vancouver Island have followed a similar trend and have comprised 16 to 22% of the annual coastwide catch since 1983.

Intertidal beaches on the west coast of Vancouver Island support small, but often dense, local populations of intertidal clams. Because of their remoteness and distance from markets, which has made harvesting in some areas uneconomical, many of these beaches were not harvested or were underutilized in the past.

Recent changes in market conditions and current socioeconomic trends resulted in an increase in digger effort and clam landings and a shift in species composition in the catch from almost all of the areas on the west coast of Vancouver Island. This change resulted from a shift in market demand from butter clams to "steamer clams" (littleneck and manila clams) in the early 1980's (Ketchen et al. 1983).

Between 1951 and 1980 butter clams comprised a major portion of annual reported British Columbia commercial intertidal clam landings. Reported landings ranged from a low of 916 t to a high of 1608 t and represented 38 to 92% of the annual catch prior to 1981. Since 1981 butter clam landings have declined significantly and comprised only 2% (65 t) of the total clam landings in 1987 (Table 2, Fig. 2). From 1951 to 1963 butter clams comprised almost 100% of the total reported catch on the west coast of Vancouver Island with landings ranging

from 2.4 t in 1951 to 115 t in 1963. Since 1964, landings of butter clams from this area have been negligible (Table 1, Fig. 2). The decline in butter clam landings is related to the high cost of canning clams, competition from imported product and the long period retention of Paralytic Shellfish toxins (PSP) by this species, rather than to a decline in stocks. Coincidental to this decline there has been a marked increase in the reported landings of littleneck and manila clams (steamer clams) which are generally sold fresh.

Littleneck clams are native to British Columbia. Manila clams were accidentally introduced into British Columbia along with Japanese oyster (Crassostrea gigas) seed and were first recorded on the east coast of Vancouver Island in 1936 (Quayle and Bourne, 1972). They were abundant in Barkley Sound on the west coast of Vancouver Island in the early 1950's (Bourne, 1982). By the late 1950's manila clams were established in Esperanza Inlet and in 1966 manila clams were reported from Quatsino Sound.

Bourne (1982) suggests that manila clams were introduced with oyster seed in Barkley Sound, however the exact history of their introduction and dispersal on the west coast of Vancouver Island is not well documented. The manila clam has spread along the entire west coast of Vancouver Island in 20 to 30 years and is now one of the major intertidal bivalves occurring on most clam beaches. At present it is the main species harvested in the commercial clam fishery.

Under ideal conditions manila clam larvae likely drift in the water column for a period of three to four weeks before settling in the intertidal zone of the beach. During this period, the larvae could drift out of a Sound, enter another Sound and settle and establish a population (Bourne, 1982). Inshore currents along the west coast of Vancouver Island have a northeast direction (Tully, 1937). Manila clam larvae were likely carried from Barkley Sound north to other Inlets. Local recruitment probably occurs in most areas once a population becomes established. This local recruitment may maintain beach populations in a general area but spawning on any given beach may not result in significant recruitment to that same beach.

Since 1964 steamer clams have been the major species harvested from the west coast of Vancouver Island. Reported landings of littlenecks ranged from a low of 0.2 t in 1953 to a high of 87 t in 1980. Manila clams have shown a larger variation in catch, ranging from 3.2 t in 1964 to 686 t in 1987. Currently manila clams comprise 80 to 95% of total clam landings on the west coast of Vancouver Island. Landings reported as mixed clams, which tend to be largely littlenecks and manilas due to difficulties of diggers and processors distinguishing these species, have ranged from 2.7 t in 1976 to 73 t in 1984 (Table 1).

Commercial clam fisheries have occurred in most areas on the west coast of Vancouver Island, however, because of their closer proximity to road access and markets, Barkley and Clayoquot Sounds (Areas 23 and 24) have accounted for the majority of the reported catch. Up to the late 1970's most butter clams were landed from Area 24 and most littleneck and manila clams from Area 23. Between 1979 and 1982, due to extended closures in Area 23, most manila clams were landed in Area 24. Since 1982, with the increased demand for manila clams,

there have been record landings of this species from all areas on the west coast of Vancouver Island (Tables 3 to 5 and Figs. 3 and 4).

Only minor and periodic landings of clams were reported from Areas 26 and 27, because of remoteness, limited road access and distance to markets. However, with the recent increase in demand for clams there has been a growing interest in harvesting many beaches there. In 1987 manila clam landings from Area 26 were 107 t. In 1963 total landings of all species from this area were less than 7 t (Tables 6 and 7 and Fig. 4).

The large fluctuations in commercial clam landings on the west coast of Vancouver Island have been due to a variety of reasons, primarily market and socioeconomic conditions, rather than limiting clam populations (Bourne and Farlinger, 1982; Bourne, 1986).

PARALYTIC SHELLFISH POISONING (PSP)

A problem that seriously affects commercial clam fisheries on the west coast of Vancouver Island is the periodic outbreaks of paralytic shellfish poisoning (PSP), a condition that occurs when bivalves feed on Protogonyaulax catenella or P. actenella (Quayle, 1969; Ketchen et al., 1983). This has limited clam harvest on the west coast of Vancouver Island and has caused precautionary closures of most areas.

In British Columbia toxic shellfish are known to occur along the entire coastline, although in any one year distribution of PSP tends to be highly localized (Bond, 1975). High levels of PSP may occur in bivalves from any area mostly between the months of May and October inclusive (Quayle and Bourne, 1972). However, toxicity may occur throughout the year due to the ability of certain species to retain the toxins for a considerable time. Butter clams, for example, can retain toxic levels of PSP for more than two years (Quayle and Bourne, 1972).

PSP control in one form or another has been in effect in British Columbia since 1942 (Bond, 1975). Regular monitoring of PSP levels in shellfish stocks has occurred in most areas on the west coast of Vancouver Island since 1963. However, due to the local nature of the outbreaks and remoteness of most areas, adequate control of shellfish quality solely through monitoring is not possible.

In order to ensure safe levels of PSP in commercially harvested bivalves a year round closure of all west coast areas was established through an Order in Council in 1971. Under this order commercial clam harvesting was allowed only during the low risk period of November through April in areas where clams had acceptably low levels of PSP. This was administered through a permit issued to federally registered shellfish processing plants which allowed further monitoring of PSP levels prior to clams entering the market. The rationale for the permit system was to provide industry with an opportunity to conduct controlled harvesting for selected species of clams in closed areas without endangering consumer safety.

In 1983, under the Pacific Fisheries Area Management Regulations, the permit system was abandoned. These regulations allowed for the controlled harvesting of bivalves in any sub-area for a specific period. Under federal inspection regulations all commercially harvested bivalves must be landed at federally registered processing plants where further monitoring of PSP levels can occur. Generally, areas on the west coast which have low levels of PSP are opened only during the six month low risk period of November through April during the winter months when weather conditions are poor and most low tides are at night.

CONTAMINATED AREA CLOSURES

Many intertidal beaches in British Columbia are permanently closed to clam harvest, by regulation, due to high levels of faecal coliform bacteria in the clam stocks and or in the surrounding waters. These contaminated areas occur in areas near or adjacent to sewage discharge, urban or rural runoff areas, boat basins and near industrial sites. A number of contaminated area closures occur along the west coast usually near communities, in high use recreational areas or industrial areas. These areas are small compared to open harvestable areas.

FISHERY MANAGEMENT

Up until the late 1970's management of the intertidal clam fishery in British Columbia did not pose significant problems to managers. Clam landings in most areas were small and many beaches, especially those in remote areas like the west coast of Vancouver Island, were not harvested or clam stocks on those beaches were underutilized. Intertidal clam beaches supported populations of clams comprised of an accumulation of several older year classes and diggers moved from beach to beach harvesting the accumulated older stock without seriously impacting on the total stock.

Since 1983 the British Columbia intertidal clam fishery has changed dramatically. Landings in all areas have reached record levels and most beaches on the east and west coasts of Vancouver Island have now been exploited. The accumulated stock which largely supported this fishery up to the early 1980's has been harvested in many areas and the fishery on most major beaches is now being supported largely by annual recruitment. Concerns of increased exploitation and stock depletion have resulted in the length of the harvest season becoming increasingly restrictive in many areas. Appendix 2 and 3 summarize the commercial clam closures that occurred in areas 23 and 24 during the period of 1980 through 1987.

Management of the British Columbia intertidal clam fishery has been primarily through size limit and time and area closures. Minimum size limits were set at 38 mm shell length for native littleneck and manila clams and 63 mm shell length for butter clams. Littleneck and manila clams attain a legal size at approximately four years which allows at least one spawning season prior to their entry into the fishery. Butter clams enter the fishery at about age five after

two to three seasons of spawning (Quayle and Bourne, 1972 and Bourne, 1982). Size restrictions of clams have been the simplest and most effective method of managing this fishery. They ensure that the reproductive potential in the stock is maintained and can be easily enforced at the harvest site, landing ports or processing plants. Time and area closures have functioned to decrease the annual rate of harvest in some areas but have had little effect in preventing declines in stock on most beaches.

Management by quota was attempted at Savary Island on the east coast of Vancouver Island but proved to be ineffective due to the effort required to estimate allowable catch and to monitor the landings. Despite quota limitations on commercial clam landings in this area,intertidal clam populations showed significant fluctuations in abundance (Bourne and Adkins, 1985; Bower et al. 1986).

The recent increase in effort, record landings and the increasing demand for area openings and extended harvest seasons have resulted in concerns of overharvest and stock depletion on many intertidal clam beaches on the west coast of Vancouver Island. There is an increasing need to develop management plans for the commercial intertidal clam fishery on the west coast of Vancouver Island to ensure that clam harvest does not exceed sustainable levels. It was the intent of this study to identify the major commercial clam beaches on the west coast of Vancouver Island and to monitor changes in clam abundance in these areas over the period of several years. From this it may be possible to identify some of the effects of commercial harvesting on intertidal clam stocks and thereby make recommendations for improved management of this fishery.

METHODS

During the years 1981 through 1987 a series of clam stock surveys was conducted on 26 beaches on the west coast of Vancouver Island in fisheries management Areas 23, 24, and 25 (Fig. 1). All sampled beaches were identified by local fishery officers as having supported commercial clam fishing. Not all beaches were surveyed each year.

At most locations, clams were sampled from a series of plots evenly spaced 25 m apart over the estimated clam bearing area. At Atleo River and Whiskey Jenny beaches in Area 24, sample plots were located according to the methods of Bourne and Farlinger (1982). Beaches were sampled during periods of low tides where tidal heights ranged from 0 to +1 metre.

Sample plots were either 0.5 or 0.25 m in area and all were dug to a depth of about 30 cm with short handled rakes. At each plot the substrate was carefully sifted through the fingers and all visible littleneck, manila and butter clams collected. This method is effective at sampling 95% of the clams 20 mm in shell length and larger (Bourne and Farlinger, 1982). Sampling

clams smaller than 20 mm is time consuming and because clams of this size may suffer heavy mortalities prior to entering the fishery, those data are of limited use for management purposes. Estimating year class strengths of clams less than 20 mm may lead to errors if these data are to be used to predict recruitment into the fishery.

Clams removed from each plot were stored in labelled plastic bags and frozen for transportation and later analysis. For each sample plot, clams were separated by species, individual shell lengths measured to the nearest 1.0 mm and pooled weights by legal and sub-legal size categories recorded to the nearest 1.0 gram.

Harvestable beach areas were estimated by pacing and measuring the shoreward, seaward and lateral distribution of clams. The limits of distribution were determined when less than two of any of the three species of clams occurred in more than two sequential sample plots.

Total harvestable area for each management area was estimated from planimeter measurements of commercial clam beaches, identified by local fishery officers, on Canadian Hydrographic charts.

RESULTS

Results for all surveys carried out in Areas 23, 24 and 25 between 1981 and 1987 are shown in Tables 9, 11 and 13 and Figs. 5 to 49.

A. AREA 23 - BARKLEY SOUND

Area 23 has generally small coarse gravel beaches (0.2 to 2.1 ha in harvestable area) with mainly manila clam populations. Although native littleneck and butter clams occurred on most beaches in Barkley Sound, their abundance was low compared to manila clams in all of the sampled locations.

A total of 31 beaches were identified in Area 23 as having supported commercial clam fisheries (Table 8). Some beaches located in Pacific Rim National Park were commercially harvested in the past but are now closed by regulation and are no longer available for commercial harvest. Between 1981 and 1984, 13 beaches at nine locations in Area 23 were surveyed. Most sampling effort was concentrated on three small beaches around Hillier Island (Fig. 5) which have produced a significant portion of reported Area 23 clam landings (pers. comm. local fishery officer). Hillier Island beaches differed from many of the other commercial clam beaches in Area 23 in their close proximity to road access and their high clam abundance.

An initial survey carried out in 1979 (A. Cowan, unpublished data) at three sites at Hillier Island showed a low abundance of legal size littleneck and manila clams . The densities of legal size littlenecks were 19.2, 16.0 and 16.0 m^{-2} and of legal size manila clams 69.5, 52.0 and 121.1 m^{-2} at sites 1, 2 and 3 respectively. Hillier Island Site 1 (Fig. 5) was sampled in 1981, 1983 and 1984 but Sites 2 and 3 were sampled only in 1983 during this study. Manila clams were far more abundant at each site than were littleneck or butter clams. Between 1981 and 1983, during a closure to commercial clam harvesting in Area 23, there was a significant ($p < 0.05$) increase in abundance of legal and sublegal size manila clams at Hillier Island Site 1. In 1984, following a commercial clam opening in this area, a significant ($p < 0.05$) decrease in density of legal and sublegal size manila clams was observed at this site (Table 9).

In 1983, 11 commercial clam beaches, ranging in size from 0.1 to 1.7 ha, were sampled in Area 23. Manila clams were far more abundant at all locations than were littlenecks and butter clams occurred at only five of these sites at very low densities. The highest densities of manila clams (488 m^{-2}) were observed at the 0.5 ha beach at Lucky Creek. Only 5.2% of these clams were legal size. The highest density of legal size manilas (198 m^{-2}) was on the small 0.1 ha beach sampled at Bazette Island. Most of the other beaches sampled in 1983 had similar densities of manila clams ranging from 108 to 292 m^{-2} (Table 9).

Compared to manila clams the densities of littlenecks sampled from all locations in 1983 were low and where they did occur most were sublegal size. Densities ranged from 1.7 m^{-2} to 64.2 m^{-2}.

Results by individual beach are described in Appendix 1 and length frequency distributions for clams sampled on these beaches are shown in Figs. 9 to 11.

B. AREA 24 - CLAYOQUOT SOUND

Area 24 (Fig. 1) had larger and more numerous clam beaches, many of which were closer to road access than were most of the commercial clam beaches in the other areas sampled. Fishery Officers identified 32 commercial clam beaches in Area 24, each having harvestable areas of between 0.6 and 6.2 ha (Table 10).

Between 1981 and 1987 commercial clam stocks were sampled on six of the major clam producing beaches in Clayoquot Sound, Shelter Inlet and Tofino Inlet. Native littlenecks were most abundant on all beaches except Whitepine Cove where manila clams were more numerous. Butter clams were more abundant on the beaches surveyed in Area 24 than in any of the other areas surveyed during this study (Table 11). We were unable to sample all six beaches each year during this study. Atleo River, Whiskey Jenny and Mosquito Harbour were sampled most often between 1983 and 1987, Whitepine Cove and Warn Bay were sampled as early as 1981 and Sulphur Passage was sampled only in 1985. In 1980 Bourne and Farlinger (1982) sampled

the clam beaches at Atleo river and Whiskey Jenny. The density estimates from their surveys are shown in Table 11.

The highest densities of littleneck clams observed at of the beaches sampled during this study were at Atleo River, one of the most heavily harvested clam beaches in Area 24. Mean density of littleneck clams increased at this site from 211 to 513 m^{-2} between 1983 and 1986. In 1987 mean density of littleneck clams declined at Atleo River to 132 m^{-2}, the lowest density of littlenecks recorded at this site. The density of sublegal size littlenecks was also greater at Atleo River than at any of the other sites sampled during this study. This was the only site where there appeared to be consistent and significant annual recruitment. In 1987 the mean density of sublegal size littlenecks declined at Atleo River to only 115 m^{-2}. This was consistent with declines in density observed on all the other beaches sampled in Area 24 during that year (Table 9).

The highest densities of legal size littlenecks (102 to 111 m^{-2}) were observed at Mosquito Harbour in between 1984 and 1986. In 1987 the mean density of legal size manila clams at this site was only 41 m^{-2}. The density of sublegal size littlenecks at Mosquito Harbour decline by one-half between 1984 and 1987, from 188 to 99 m^{-2} (Table 9).

Whitepine Cove was unlike the other beaches sampled in Area 24 in that manila clams were at higher densities than were littleneck clams. The highest density of legal size manila clams estimated in Area 24 occurred at this site in 1981 where legal size manila clams were at 132 per m2. Between 1981 and 1985 densities of manila clams declined sharply at this site from 202 to only 62 m^{-2} (Table 9).

In 1985, with the exception of Atleo River, Sulphur Passage had the highest densities of littleneck and manila clams, 292 and 93 m^{-2} respectively. Like Atleo River most littlenecks were below the legal size limit. Warn Bay was sampled in 1981 and 1984. There was a slight increase in the abundance of littleneck and manila clams at this site during that time (Table 9).

There were considerable differences in densities of both legal and sublegal size clams at all sites sampled in Area 24 between 1981 and 1987. At all sites however, the lowest densities occurred in the last year surveyed.

Detailed results for each site sampled in Area 24 during this study are described in Appendix 1. Length frequency distributions for clams sampled from each site for each survey are shown in Figs. 13 to 17, 19 to 22, 24 to 26, 28 to 29, 31 to 34 and 36. Site descriptions and location of sample plots are shown in Figs. 12, 18, 23, 27, 30 and 35.

C. AREA 25 - ESPERANZA INLET

Area 25 (Esperanza Inlet and Nootka Sound) has a number of commercial clam beaches which have shown increased importance in recent years with the high market demand for steamer clams. Since 1982 landings of steamer clams from this area have increased significantly (Table 5 and Fig 4).

Local fishery officers identified 23 beaches in Area 25 (Table 12) that have supported commercial clam fisheries. Five of the major beaches in this area were surveyed in 1984; three in Mary and Inner Basins and two in Little Espinosa Inlet. No surveys were undertaken in this area between 1985 and 1987. The beaches in Little Espinosa Inlet were surveyed in 1984, as a result of concerns over increased digger pressure and possible declining stocks. Survey results are presented in Table 13, location of the sample plots and a description of the sampled beach are shown in Figs. 37, 39, 41, 43 and 45 and length frequency distributions of the clams sampled at each location are shown in Figs. 38, 40, 42, 44 and 46.

The clam beaches in Mary and Inner Basins supported experimental harvesting by a hydraulic clam harvester between 1980 and 1982. Considerable habitat disruption, clam mortalities and a decline in stock resulting from the hydraulic digger was noted on these beaches in 1981 and 1982 (Adkins et al. 1983).

With the exception of Little Espinosa Site 2, all of the beaches sampled in Area 25 during 1984 had considerably higher densities of littlenecks than manila clams. The mean density of littlenecks at this site was only 2.9 m^{-2} compared to mean densities of between 68 and 144 m^{-2} estimated at the four other beaches surveyed in this area that year (Table 13).

Mary Basin and Laurie Creek and Inner Basin were the largest beaches surveyed during this study; their estimated harvestable areas were 8.0, 5.0 and 5.0 ha respectively (Table 12). The beaches at Mary Basin and Laurie Creek had the highest densities of both legal and sublegal size littlenecks in 1984 of all five beaches sampled in Area 25. Manila clams occurred at similar densities, between 43 and 49 m^{-2}, on all of the beaches surveyed in area 25 in 1984 with the exception of Little Espinosa Site 2 where mean density was 130 m^{-2}. Butter clams occurred at very low densities on all of the beaches surveyed in this area (Table 13).

Mary Basin, Laurie Creek showed little change in density of littlenecks but an increase in the abundance of manila clams from the 1982 estimates of Adkins et al (1983). In Inner Basin there was a decline in the abundance of both littleneck and manila clams from the 1982 estimates of Adkins et al. (1983). The physical disruption to the beaches that was evident in 1982 as a result of the activity of a hydraulic clams harvester in this area was not evident on any of the beaches in Mary or Inner Basins in 1984. There was however some evidence of commercial hand digging on all of the beaches sampled in area 25 during this study.

Detailed results for each beach sampled in Area 25 during 1984 are presented in Appendix 1.

DISCUSSION

Steamer clams have comprised almost 100% of reported intertidal clam landings from the west coast of Vancouver Island since the mid 1970's. Landings reached record levels in 1980 (133 tonnes) and continued to increase rapidly through to 1987 to 730 tonnes. Since 1980 manila clams have made up 77 to 94% of the reported landings of intertidal clams from all areas on the west coast of Vancouver Island. Landings of littleneck and butter clams from west coast beaches since 1980 have been negligible, compared to manila clams.

The landings of intertidal clams from the west coast of Vancouver Island do not reflect the species composition on most beaches there. The majority of clams landed from all areas on the west coast of Vancouver Island since 1980 were manila clams whereas most of the clams occurring on most beaches sampled in these areas were littlenecks. The clam beaches sampled in each management area varied somewhat in species composition. Manila clams comprised 75 to 100% of the steamer clams on beaches sampled in Area 23 whereas they comprised only up to 27% of the steamer clams on the beaches sampled in Area 24 (except Whitepine Cove where they made up to 84% of the steamer clams) and 3 to 44% of the steamer clams sampled on the beaches in Area 25 (except Little Espinosa Site 2 where manilas were 98% of the sampled clams). The harvest of littleneck clams has not been significant on the west coast of Vancouver Island compared to that of manila clams, however littlenecks comprise the largest portion of the intertidal clam stocks in these areas.

Although manila clams are the species preferred by the market, commercial diggers cannot always target solely on this species. Littleneck clams tend to occur slightly higher on the intertidal beach than do manila clams (Quayle and Bourne, 1972) however their ranges do overlap on some beaches and littleneck clams are often dug at the same time as manilas. Declines in density of both legal and sublegal sized manila and littleneck clams were observed at almost all of the sample locations where time series data was collected during the course of this study. The declines in density of legal sized manila clams were expected and were associated with their increased exploitation, however, the declines in density of legal and sublegal sized littlenecks and sublegal sized manilas were likely the result of increased mortality associated with the increased harvesting activity.

The recent increase in exploitation of clam stocks on the west coast of Vancouver Island has raised concerns over excessive harvest and stock declines. Clam landings have increased significantly since 1980. However, the magnitude of these increases may not be as great as indicated here. Fisheries data collection though sales slip returns has been subject to gross errors in the past through under reporting and failure of some buyers to report landings altogether. Since, 1983, however, increased effort in data collection has resulted in more accurate estimates of annual harvest. The observed increases in annual landings reported here may be due at least partially to better data collection.

Results of the surveys conducted on the West Coast of Vancouver Island during the period of 1981 to 1987 showed that abundance of legal sized steamer clams varied considerably between most of the surveyed beaches. As one would expect from increasing harvest effort most of the beaches surveyed periodically showed declining trends in the density of legal sized littleneck and manila clams (Figs. 47 to 49). There was little change in the abundance of legal sized littleneck and manila clams at Atleo River between 1980 and 1986, but a significant decline in abundance of these species between 1986 and 1987. At Hillier Island there was a significant increase in the abundance of legal sized manila clams between 1981 and 1983 during a conservation closure in Area 23 but a decline in density, to below the 1981 estimate, in 1984 after the resumption of commercial harvesting in this area (Fig. 49). On many of the surveyed beaches, the declines in density were also apparent in sublegal sized littleneck and manila clams which may indicate that these size-classes suffered increased mortality through commercial harvesting activity.

Recruitment at all of the sites where time series data was collected was also variable. In Area 24 recruitment fluctuated from year to year but was not consistent between beaches (Fig. 47 and 48). At Atleo River the abundance of sublegal sized littleneck clams increased steadily between 1980 and 1986 but then declined below the 1980 estimate in 1987. The density of sublegal sized manila clams at Atleo River remained relatively constant between 1980 and 1986 but then also declined in 1987 to well below the 1980 estimate. At all sites the lowest levels of recruitment occurred in the last year surveyed (Figs. 47 to 49).

Declines in recruitment may be possibly linked to repeated digging which probably increases mortality of sublegal sized clams and reduces survival of recruits into the fishery. Many beaches are being dug as many as five or six times a year, which is damaging to the beach and to prerecruits. The optimal digging frequency for littleneck and manila clams is unknown, but it is probably no more than once a year and may be every other year (Bourne, pers. comm.).

Winter kills of manila clams as observed at locations on the east coast of Vancouver Island (Bower et al. 1986) may have also played an important role in the declining densities observed during these studies. Mortality of manila clams, similar to that observed on the east coast of Vancouver Island resulting from winter kills, was noted on at least two beaches in Area 25 in March 1986 (B. Hume, pers. comm.). It is likely that other beaches were also affected by similar mortalities at that time and that this could at least partially account for some of the declines in population abundance and recruitment of manila clams observed between 1986 and 1987.

No data are available documenting the quantity of clams removed from or the frequency of digging of any specific beach on the west coast of Vancouver Island during the period of this study, hence it is impossible to correlate the observed declines in clam density on the sampled beaches directly to commercial clam harvesting activity or to digging frequency. Further studies need to be undertaken to determine the direct effect of clam harvest activity on clam abundance.

A number of commercial closures occurred in Areas 23 and 24 during the period of this study (Appendix 2 and 3). PSP closures were in effect in all west coast areas from May 1 to October 31 each year. In addition, specific beach areas and or management subareas were closed to commercial harvesting of littleneck, manila and butter clams for varying times during the periods of January 1 to April 30 and November 1 to December 31 of certain years for conservation reasons resulting from intensive digging pressure or perceived declining stocks. These closures varied in length from three weeks to three years and were initiated to prevent commercial clam harvesting and to allow clam abundance to increase at specific locations.

Not all sites were sampled annually, hence it is not possible to ascertain the effects of some of the conservation closures at some locations. At all sites, with the exception of Hillier Island in Area 23 and Atleo River in Area 24, where sampling occurred before, during and after conservation closures, there appeared to be little change in the abundance of littleneck and manila clams compared to those sites which were not closed during the period of this study.

The conservation closures at Atleo River January 1 to April 30, 1985 and 1986 had little effect on clam abundance. The density of legal and sublegal sized littlenecks increased each year from 1983 to 1986 regardless of the closures. There was no significant change in the abundance of manila clams at this site between 1981 and 1986.

The most significant changes resulting from a conservation closure were observed at Hillier Island between 1981 and 1983 where the density of manila clams increased by 66%. During the three year closure in Area 23 clams at Hillier Island could settle, grow, recruit and spawn without disturbance by commercial harvesters. In addition, in the absence of harvesting survival of sublegal size-classes likely increased compared to beaches like those at Atleo River where survival of sublegal sized clams was subject to at least some harvesting activity during the closure period.

Following a six week opening in Area 23 in early 1983, a significant decline in abundance of both legal and sublegal sized manila clams was observed at Hillier Island in February 1984. Closures at most other sampled locations were not of sufficient length to show significant changes in abundance resulting from renewed harvest effort.

The effects of short term beach closures on clam abundance in Area 24 appeared to be minimal. At each site surveyed during or following a closure there was some increase in the abundance of sublegal sized littlenecks but little change in the abundance of legal sized littlenecks or in the abundance of legal or sublegal sized manilas. The increase in abundance of sublegal sized littlenecks at Atleo River (Fig. 47) may have been the result of settlement of one or two strong year classes and may have been independent of the closure. From this it appears that short periods of closures of a few weeks to a few months have little or no effect on local recruitment or on increasing the density of legal sized clams compared to longer periods of closure of up to three years.

In order to increase the abundance of commercial clams on any harvested beach it may be necessary to close a site for three or more years or to reduce the frequency of harvest during open times. In the absence of harvesting activity clam densities would increase by: (i) growth of sublegal size clams to legal size, (ii) increased survival of sublegal sized clams and (iii) successful settlement and recruitment to the beach during the period of closure. The closures that have been in effect in Area 24 to date have been more effective at reducing short term effort than in actually increasing clam abundance. In order to determine the optimal length of time for conservation closures it will be necessary to undertake further studies.

If current market demands for intertidal clams continue then annual landings of manila clams from the west coast of Vancouver Island can be expected to increase to a point where they will stabilize or begin to decline. Declines in landings and stock abundance may be due to fluctuations in recruitment or continued high rates of exploitation. A decline in landings is expected as harvesters remove the accumulated older year-classes from the most accessible and productive beaches and then are forced to move to the more remote less productive beaches. If harvesting continues at the same rate or increases then annual landings of manila clams from beaches on the west coast of Vancouver Island will be largely dependant on annual recruitment to the fishery and landings from most areas can be expected to fluctuate with year-class strengths. There may be a large potential for increased landings of littleneck clams from most west coast areas as this species has largely been ignored by the fishery to date. Proportionally, most west coast beaches could support larger landings of littleneck clams than manila clams.

Minimum legal size limits and time and area closures have worked well in managing the commercial clam fishery on the west coast of Vancouver Island to date. The length of time for closures and the frequency of harvest need to be further evaluated so that conservation needs are addressed. Conservation closures may have to be for periods of up to three years or more if local stocks are expected to accumulate and increase or recover from excessive harvesting. Rotational fisheries or short open periods may have to be considered if harvest frequency of specific beaches are to be reduced to only one or two times annually. Continued surveys and studies of beaches in each management area should be undertaken in conjunction with experimental management to more closely determine the effects of harvesting on intertidal clam stocks and the optimum lengths of closures and optimum harvest frequencies.

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Table 1. Annual landings (tonnes) of intertidal clams from the west coast of Vancouver Island (Areas 23 to 27) as reported on sales slips; 1951 to 1987.

Year	Total Landings (t)	Butter (t)	Littleneck (t)	Manila (t)	Mixed (t)
1951	0.0				
1952	0.0				
1953	2.6	2.4	0.2		
1954	2.5	2.1	0.4		
1955	114.0	114.0			
1956	17.0	17.0			
1957	53.0	53.0			
1958	0.0				
1959	19.0	19.0			
1960	3.4	3.4			
1961	4.4	4.4			
1962	43.0	43.0			
1963	115.0	115.0			
1964	43.5	26.0	14.3	3.2	
1965	104.5	11.0	37.5	56.0	
1966	195.7	12.0	55.7	128.0	
1967	72.9	0.9	49.0	23.0	
1968	43.4	0.4	12.0	31.0	
1969	19.0	10.0	1.5	7.5	
1970	17.4	14.0	3.3	0.1	
1971	19.8	5.4	5.5	8.9	
1972	55.0	2.5	43.0	9.5	
1973	15.6	0.5	11.0	4.1	
1974	23.5		4.5	19.0	
1975	111.9	3.2	21.0	85.0	2.7
1976	57.3		20.0	25.0	12.3
1977	58.6		4.2	49.0	5.4
1978	26.9	1.0	3.9	21.0	1.0
1979	28.5		8.5	20.0	
1980	133.0	10.0	87.0	36.0	
1981	30.5	0.4	11.0	16.0	3.1
1982	148.2		17.0	129.0	2.2
1983	273.6	0.7	16.0	240.0	16.9
1984	490.1	3.4	35.4	378.0	73.3
1985	619.3		12.5	548.0	58.8
1986 *	438.6	3.6	20.9	387.0	27.1
1987	729.5	8.3	24.5	686.0	10.7

* Area 23 was closed in 1986 due to conservation concerns

Table 2. British Columbia annual intertidal clam landings (tonnes) and landed values (10^3); 1951 to 1987, as reported on sales slips.

Year	Total Landings (t)	Landed Values ($000)	Butter (t)	Littleneck (t)	Manila (t)	Mixed (t)
1950						
1951	1916	149	1598	237	81	
1952	2901	222	2493	224	184	
1953	1991	127	1675	140	176	
1954	1585	104	1315	66	204	
1955	2415	159	2172	36	207	
1956	1568	102	1455	14	99	
1957	1647	102	1608	10	29	
1958	1021	65	988	18	15	
1959	1142	75	1095	22	25	
1960	1848	133	1801	41	6	
1961	923	76	829	46	48	
1962	1681	139	1520	92	69	
1963	1360	103	1242	59	59	
1964	665	59	570	69	26	
1965	884	106	705	82	97	
1966	1086	125	832	105	149	
1967	1207	163	976	139	92	
1968	654	98	399	91	164	
1969	565	85	378	107	80	
1970	1032		793	145	79	15
1971	1094	235	569	361	153	11
1972	1544	382	646	632	265	1
1973	640	196	297	207	136	
1974	1042	383	531	328	183	
1975	1147	333	747	236	158	6
1976	1098	340	656	173	199	70
1977	1313	545	650	209	394	60
1978	1843		686	159	753	245
1979	1511	916	613	273	251	374
1980	1557	1001	760	358	288	151
1981	776	737	120	178	317	161
1982	1090	1141	103	237	595	155
1983	1696	1687	77	325	1014	280
1984	2513	2512	131	295	1677	410
1985	2831	3144	252	191	1910	478
1986	2709	3805	159	285	1894	371
1987	4069	6522	65	373	3544	87

Table 3. Annual landings (tonnes) of intertidal clams from Area 23, as reported on sales slips; 1951 to 1987.

Year		Total Landings (t)	Butter (t)	Littleneck (t)	Manila (t)	Mixed (t)
1950						
1951						
1952						
1953						
1954						
1955		104.0	104.0			
1956						
1957						
1958						
1959				1.0		
1960		18.2	18.2			
1961						
1962						
1963		3.3	3.3			
1964		19.2	1.7	14.3	3.2	
1965		98.3	4.9	37.5	55.9	
1966		189.0	6.8	54.7	127.5	
1967		72.9	0.9	49.0	23.0	
1968		43.3	0.4	11.5	31.4	
1969		7.8		0.3	7.5	
1970						
1971		1.8		1.8		
1972		4.4		4.4		
1973		1.0	0.5	0.5		
1974		19.0			19.0	
1975		82.2		6.4	73.1	2.7
1976		37.7		2.7	22.7	12.3
1977		23.6		1.4	18.6	3.6
1978		10.0		0.9	9.1	
1979		2.7		0.5	2.2	
1980						
1981						
1982						
1983	*	95.8		7.8	82.7	5.3
1984	*	122.0		27	27.2	67.8
1985	*	40.5		1.4	29.7	9.4
1986	*	2.7			2.5	0.2
1987	*	110.0	5.5	0.2	104.3	

* five year average 1983 to 1987 - 74.2 t; closed in 1986

Table 4. Annual landings (tonnes) of intertidal clams from Area 24, as reported on sales slips; 1951 to 1987.

Year	Total Landings (t)	Butter (t)	Littleneck (t)	Manila (t)	Mixed (t)
1950					
1951					
1952					
1953	2.6	2.4	0.2		
1954					
1955	9.5	9.5			
1956	16.6	16.6			
1957	31.9	31.9			
1958					
1959	19.0	19.0			
1960	3.3	3.3			
1961	4.4	4.4			
1962	26.1	26.1			
1963	59.2	59.2			
1964	24.5	24.5			
1965					
1966	6.1	5.1	1.0		
1967					
1968					
1969	11.2	10.0	1.2		
1970	17.4	14.0	3.3	0.1	
1971	0.0				
1972	0.3		0.3		
1973					
1974					
1975	3.2		0.9	2.3	
1976	0.5			0.5	
1977	31.4		1.4	29.1	0.9
1978	9.0	1.0	2.0	6.0	
1979	26.0		8.0	18.0	
1980	116.0	9.0	79.0	28.0	
1981	20.1	0.4	7.3	9.4	3.0
1982	120.6		15.2	105.3	0.1
1983 *	124.2		2.3	111.9	10.0
1984 *	202.1		6.7	195.3	0.1
1985 *	273.5		9.5	247.7	16.3
1986 *	157.8		4.2	146.5	7.1
1987 *	213.6	0.3	7.7	205.0	0.6

* five year average, 1983 to 1987 - 194 t.

Table 5. Annual landings (tonnes) of intertidal clams from Area 25, as reported on sales slips; 1951 to 1987.

Year	Total Landings (t)	Butter (t)	Littleneck (t)	Manila (t)	Mixed (t)
		1951 to 1962 - no reported landings			
1963	10.2	10.2			
1964					
1965	6.2	6.2			
1966					
1967					
1968					
1969					
1970					
1971	18.0	5.4	3.7	8.9	
1972	49.2	2.5	37.2	9.5	
1973	11.4		8.2	3.2	
1974	3.6		3.6		
1975	25.9	3.2	13.6	9.1	
1976	19.6		17.7	1.9	
1977	1.8			0.9	0.9
1978	7.0			6.0	1.0
1979					
1980	6.0		2.0	4.0	
1981	9.8		3.0	6.7	0.1
1982	20.5		1.3	17.1	2.1
1983 *	48.5	0.7	2.2	45.5	0.1
1984 *	87.2	0.4	0.7	80.9	5.2
1985 *	157.5		1.6	144.0	11.9
1986 *	230.1	3.6	11.7	195.5	17.3
1987 *	268.0		14.1	245.6	8.3

* five year average, 1983 to 1987 - 158 t.

Table 6. Annual landings (tonnes) of intertidal clams from Area 26, as reported on sales slips; 1951 to 1987.

Year	Total Landings (t)	Butter (t)	Littleneck (t)	Manila (t)	Mixed (t)
		1951 to 1962 - no reported landings			
1962	16.9	16.9			
1963	42.8	42.3	0.5		
		1964 to 1971 - no reported landings			
1972	0.9		0.9		
1973					
1974	0.9		0.9		
1975	0.5		0.5		
1976					
1977	1.4		1.4		
1978	1.0		1.0		
1979					
1980	6.0		2.0	4.0	
1981					
1982	1.6			1.6	
1983 *					
1984 *	78.5	3.0	1.0	74.5	
1985 *	119.8			98.6	21.2
1986 *	26.5		3.0	22.5	1.0
1987 *	113.6	2.5	1.9	107.4	1.8

* five year average, 1983 to 1987 - 85 t.

Table 7. Annual landings (tonnes) of intertidal clams from Area 27, as reported on sales slips; 1951 to 1987.

Year	Total Landings (t)	Butter (t)	Littleneck (t)	Manila (t)	Mixed (t)
1951 to 1972 - no reported landings					
1973	3.6		2.7	0.9	
1974					
1975					
1976					
1977					
1978					
1979					
1980	5.0	1.0	4.0		
1981	0.3		0.3		
1982	5.6			5.6	
1983 *	5.3		3.8		1.5
1984 *	0.1				0.1
1985 *	28.4			28.4	
1986 *	12.5		2.0	9.0	1.5
1987 *	24.0		0.6	23.4	

* five year average, 1983 to 1987 - 14 t.

Table 8. Estimated harvestable areas (ha) of commercial clam beaches in Area 23.

Beach	Commercial Beach Areas (ha) 1	2	3	4	5	Harvestable Area
* Useless Inlet (I)	0.9	0.6	0.5			1.9
* Useless Inlet (II)	0.5	0.3	0.1			0.9
Rainy Bay	0.5					0.5
Congreve Island	1.1	0.2	0.2	0.2		1.7
Santa Maria Island	1.0					1.0
Effingham Inlet	1.0	0.8	0.5			2.3
* Vernon Bay	0.4	2.3				2.6
Alma Russell Islands	0.5	0.7	0.6	0.3		2.1
Julia Passage	0.7	0.3	0.4			1.4
* Hillier Island	0.7					0.7
* Cataract Creek	1.2	1.1				2.3
Toquart Bay (west side)	1.7	1.2	1.2			4.0
Stopper Islands	0.7	0.5	0.7	0.6	0.6	3.0
Larkins	0.5					0.5
Mayne Bay	0.4	0.9	0.8	0.4	0.2	2.7
* Harris Point	0.9	0.9				1.9
Equis Beach	2.1					2.1
* Pinkerton Islands	0.2	0.3	0.1	0.3	3.1	4.0
Brabent Islands	0.5	0.8	0.9			2.2
Grappler Inlet	1.5					1.5
Seachart Channel	1.0	0.5				1.5
Trebel Island	0.5					0.5
Roquefeuil Bay	1.3	1.0	0.4			2.6
Pipestem Inlet	0.7	0.7				1.4
Robber Passage	1.2	0.7				1.9
* Lucky Creek	0.5					0.5
Ritherson Bay	1.4					1.4
Sproat Bay	2.4					2.4
John Islet	0.5					0.5
Canoe Island	1.5					1.5
* Bazette Island	0.7					0.7
Total Harvestable Area						**54.1**

Commercial beach areas are individual clam bearing beaches at each location

* survey sites

Table 9. Mean densities (clams m^{-2}) of littleneck, manila and butter clams on beaches sampled in Area 23 between 1981 and 1984.

Surveyed Beaches	Year	Harvestable Area (ha)	Clams m-2								
			Littleneck			Manila			Butter		
			Legal	Sublegal	% legal	Legal	Sublegal	% legal	Legal	Sublegal	% legal
HILLIER ISLAND SITE 1	1981	1.7	1.0	9.8	9.3	62.8	154.0	29.0	0.0	4.8	0.0
	1983		2.4	9.2	20.7	126.0	234.0	35.0	0.0	0.0	0.0
	1984		0.5	0.5	50.0	42.3	148.0	22.2	0.0	0.0	0.0
HILLIER ISLAND SITE 2	1983	0.2	5.3	22.0	19.5	94.8	197.0	32.5	0.0	0.0	0.0
HILLIER ISLAND SITES 3&4	1983	0.3	0.4	1.3	24.9	45.8	249.0	15.5	0.0	0.0	0.0
BAZETTE ISLAND	1983	0.1	0.7	4.7	12.5	189.0	69.3	73.2	0.0	0.0	0.0
VERNON BAY SITES 1 - 3	1983	1.0	1.1	63.1	1.8	125.7	63.7	66.4	0.0	4.0	0.0
USELESS INLET	1983	1.2	5.8	42.2	12.0	127.0	50.7	71.5	0.0	4.9	0.0
PINKERTON ISLANDS SITES 1-3	1983	1.4	16.0	14.2	53.0	39.4	68.6	36.5	2.6	4.0	39.4
STOPPER ISLANDS	1983	0.2	4.5	5.5	45.0	58.5	223.0	20.8	0.5	1.5	25.0
HARRIS POINT	1983	0.5	4.0	4.0	50.0	91.3	191.0	32.3	0.0	0.0	0.0
CATARACT CREEK	1983	0.2	0.0	0.0	0.0	33.8	101.0	25.1	0.0	0.0	0.0
LUCKY CREEK	1983	0.5	0.0	0.0	0.0	25.3	463.0	5.2	0.0	0.0	0.0

Table 10. Estimated harvestable areas (ha) of commercial clam beaches in Area 24.

Location	Commercial Beach Areas (ha) 1	2	3	4	5	Harvestable Area
* Whitepine Cove	1.6					1.6
Lower Whitepine Cove	2.0					2.0
George Island	1.1					1.1
Dixon Island	1.3	3.3				4.6
* Atleo River	1.7	1.6				3.3
Hayden Passage	1.0					1.0
* Sulphur Passage	1.1					1.1
Obstruction Island	0.2	0.5				0.7
Rae Basin	0.7					0.7
Hesquiat Harbour	0.8					0.8
Dawley Passage	0.9					0.9
Indian bay	1.4					1.4
Beck Island	2.1					2.1
Riley Island	0.5					0.5
Morpheus Island	0.6					0.6
MacKenzie Beach	0.7					0.7
Frank Island	1.4					1.4
Cox Bay	1.4	0.5	1.1			2.9
* Warn Bay	1.0	0.5	0.8	1.2		3.5
* Mosquito Harbour	2.0	0.6				2.6
* Whiskey Jenny	4.3					4.3
Meares Island	4.8					4.8
Total Harvestable Area						42.5

Commercial beachareas are areas of individual clam bearing beaches at each location

* survey sites

Table 11. Mean densities (clams m^{-2}) of littleneck, manila and butter clams on beaches sampled in Area 24 between 1981 and 1987.

Surveyed Beaches	Year	Harvestable Area (ha)	Clams m-2								
			Littleneck			Manila			Butter		
			Legal	Sublegal	% Legal	Legal	Sublegal	% Legal	Legal	Sublegal	% Legal
ATLEO RIVER	1980 1.	3.0	103.4	168.8	38.0	33.0	63.1	34.3	32.4	57.3	36.1
	1983		33.5	207.5	13.9	46.9	67.5	41.0	12.4	27.7	30.9
	1984		52.7	227.0	18.8	18.5	30.1	38.1	29.2	40.1	42.1
	1985		61.1	377.1	13.9	41.8	50.2	45.5	20.7	38.6	35.0
	1986		77.3	435.6	15.1	50.0	68.0	42.4	9.1	39.8	18.6
	1987		17.1	115.3	12.9	2.5	9.0	21.7	11.3	30.8	26.8
WHISKEY JENNY	1980 1.	4.3	48.4	86.7	35.8	3.1	9.3	25.0	13.5	38.4	26.0
	1983		35.8	58.0	38.2	1.7	1.4	55.0	17.5	34.6	33.6
	1984		37.3	28.1	57.0	1.0	0.4	69.9	9.9	14.0	41.3
	1985		23.5	57.0	29.2	3.3	3.8	46.5	19.3	37.8	33.8
	1987		15.4	43.1	26.3	0.0	0.0	0.0	6.6	11.5	36.5
WHITEPINE COVE	1981	3.0	14.1	53.4	20.9	131.6	71.8	64.7	1.1	12.2	8.5
	1984		3.1	12.6	19.9	54.0	26.1	67.4	0.5	1.0	33.3
	1985		2.1	27.6	7.2	37.3	25.1	59.8	0.4	2.9	11.7
WARN BAY	1981	1.2	44.2	91.0	32.7	0.0	0.2	0.0	3.9	8.8	30.7
	1984		53.0	97.0	35.3	9.8	9.4	51.0	3.3	15.9	17.0
MOSQUITO HARBOUR	1984	0.6	111.0	188.0	37.1	56.9	11.3	83.4	0.2	9.6	2.2
	1985		101.7	65.4	60.9	24.5	13.3	64.8	1.2	6.0	16.3
	1986		111.0	99.2	52.8	19.7	14.3	57.9	0.0	0.0	0.0
	1987		41.1	63.2	39.4	11.1	4.8	69.9	0.2	5.9	2.5
MOSQUITO HARBOUR SITE 4	1986		110.8	73.5	60.1	8.3	5.8	58.9	0.0	0.0	0.0
	1987		30.7	46.0	40.0	8.0	4.9	62.1	1.6	9.1	14.6
SULPHUR PASSAGE	1985	1.1	40.4	251.8	13.8	65.1	28.2	69.8	5.3	8.0	40.0

1. data from Bourne and Farlinger, 1980

Table 12. Estimated harvestable areas (ha) of commercial clam beaches in Area 25.

Location	Commercial Beach Areas (ha) 1.					Harvestable Area
	1	2	3	4	5	
* Little Espinosa Inlet	0.6					0.6
Espinosa Inlet	4.9	2.0	2.6			9.5
Graveyard Bay	1.5					1.5
Ehatisa Harbour	1.8					1.8
Port Eliza	2.7	1.5				4.1
Eliza Island	6.2					6.2
Queen Cove	4.7					4.7
* Laurie Creek	2.1					2.1
* Mary Basin	3.4					3.4
* Inner Basin	2.1					2.1
Hecate Channel	0.9	1.1	0.5			2.5
Esperanza Inlet	2.6	0.8	0.7			4.1
Kendrick Inlet	5.4	1.1	1.5	1.1		9.1
Tlupana Inlet	1.5	2.1	2.1			5.7
Strange Island	1.1					1.1
Ewin Inlet	0.5	0.0				0.5
Jewitt Cove	0.4					0.4
Tsowwin Narrows	2.4					2.4
McBride bay	0.5	0.2				0.7
Nuchatlitz Creek	1.6					1.6
Garden Point	1.1	0.3				1.4
Nuchatlitz	1.2	0.7				1.9
Louie Bay	6.1					6.1
Total Harvestable Area						73.2

Commercial beach areas are areas of individual clam bearing beaches at each loca

* surveyed sites

Table 13. Mean densities in (clams m^{-2}) of littleneck, manila and butter clams on beaches sampled in Area 25 between 1981 and 1987.

Surveyed Beaches	Year	Harvestable Area (ha)	Clams m-2								
			Littleneck			Manila			Butter		
			Legal	Sublegal	% Legal	Legal	Sublegal	% Legal	Legal	Sublegal	% Legal
MARY BASIN	1981 1.	8.0	49.9	36.5	57.8	8.9	7.0	55.8	1.8	6.8	21.2
	1982 1.		63.7	76.4	45.5	4.0	1.7	69.9	5.4	13.0	29.4
	1984		63.5	80.5	44.1	18.1	24.8	42.2	4.7	13.1	26.5
LAURIE CREEK	1981 1.	5.0	31.1	34.6	47.4	24.0	6.0	80.0	1.4	3.4	29.4
	1982 1.		47.3	97.4	32.7	10.7	10.7	50.0	0.7	0.7	50.4
	1984		50.3	80.2	38.5	29.4	14.3	67.3	1.7	9.5	15.2
INNER BASIN	1981 1.	5.0	40.7	108.0	27.3	174.0	94.0	64.9	0.0	0.0	0.0
	1982 1.		108.3	108.0	50.1	75.0	8.3	90.0	0.3	0.0	100.0
	1984		38.7	29.2	57.0	42.9	5.6	88.5	0.1	0.2	33.3
LITTLE ESPINOSA SITE 1	1984	1.50	50.9	55.2	48.0	17.1	27.7	38.2	0.8	1.3	37.6
LITTLE ESPINOSA SITE 2	1984	0.75	1.5	1.4	52.4	59.5	70.5	45.8	0.0	4.5	0.0

1. Data from Adkins et al. 1983.

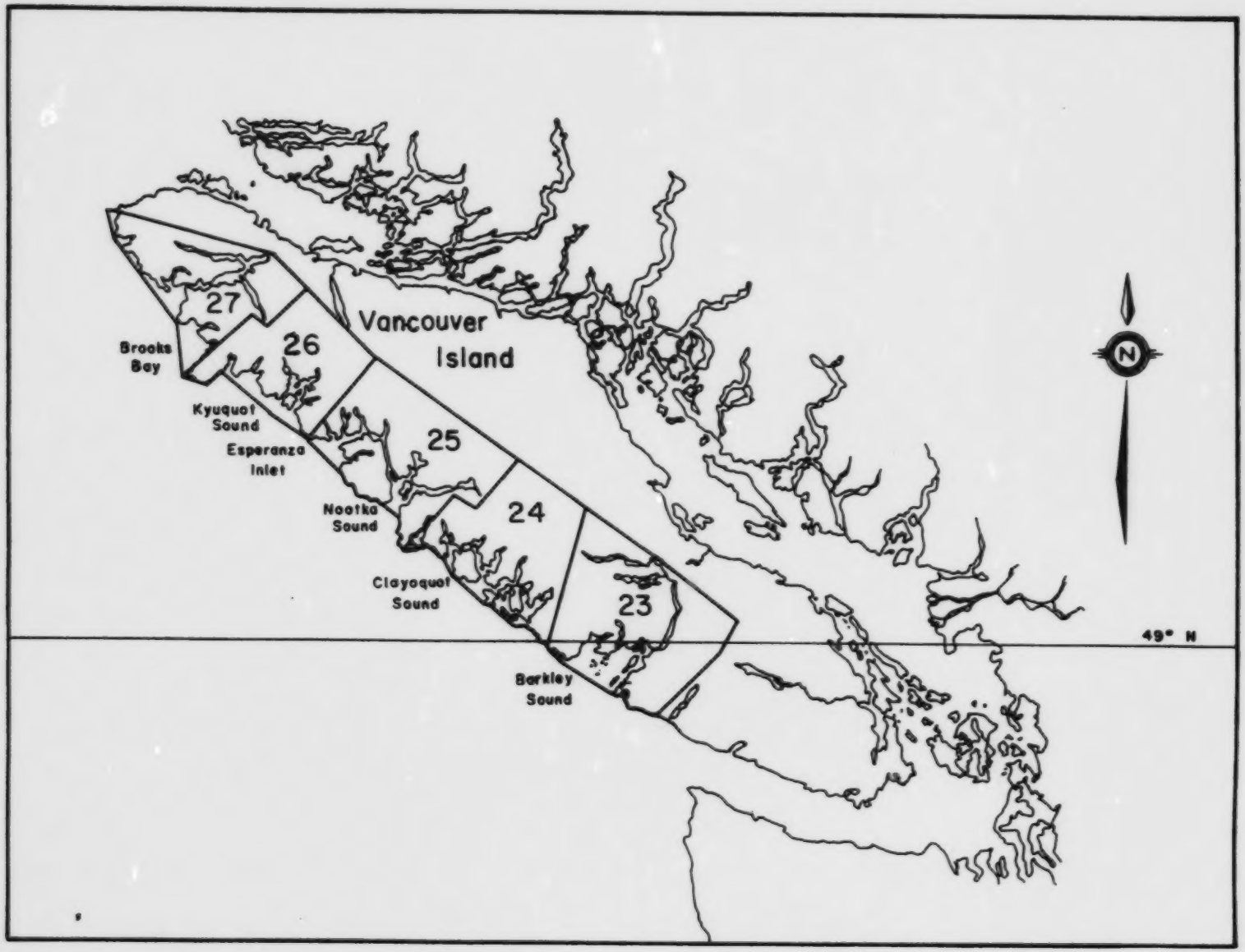

Figure 1. Pacific Fisheries Management Areas 23 to 27.

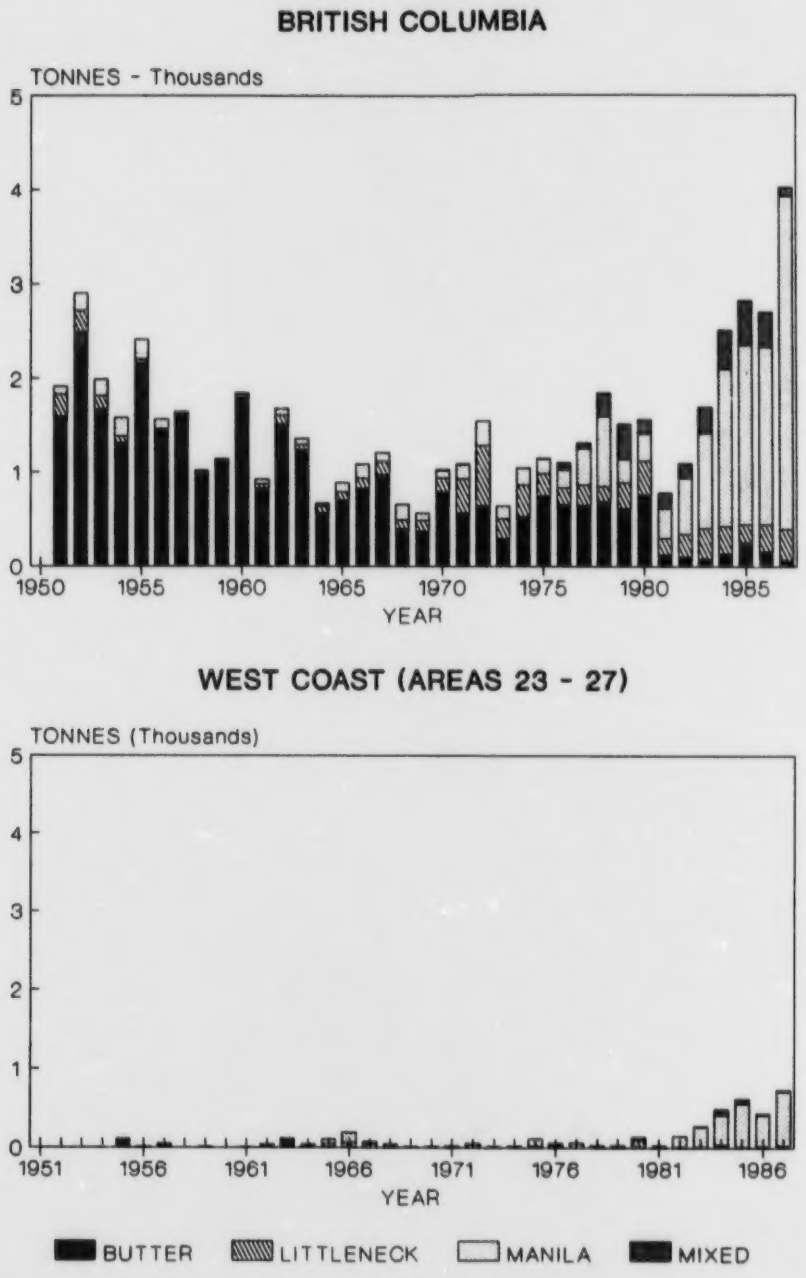

Figure 2. Annual British Columbia intertidal clam landings (tonnes); 1951 to 1987.

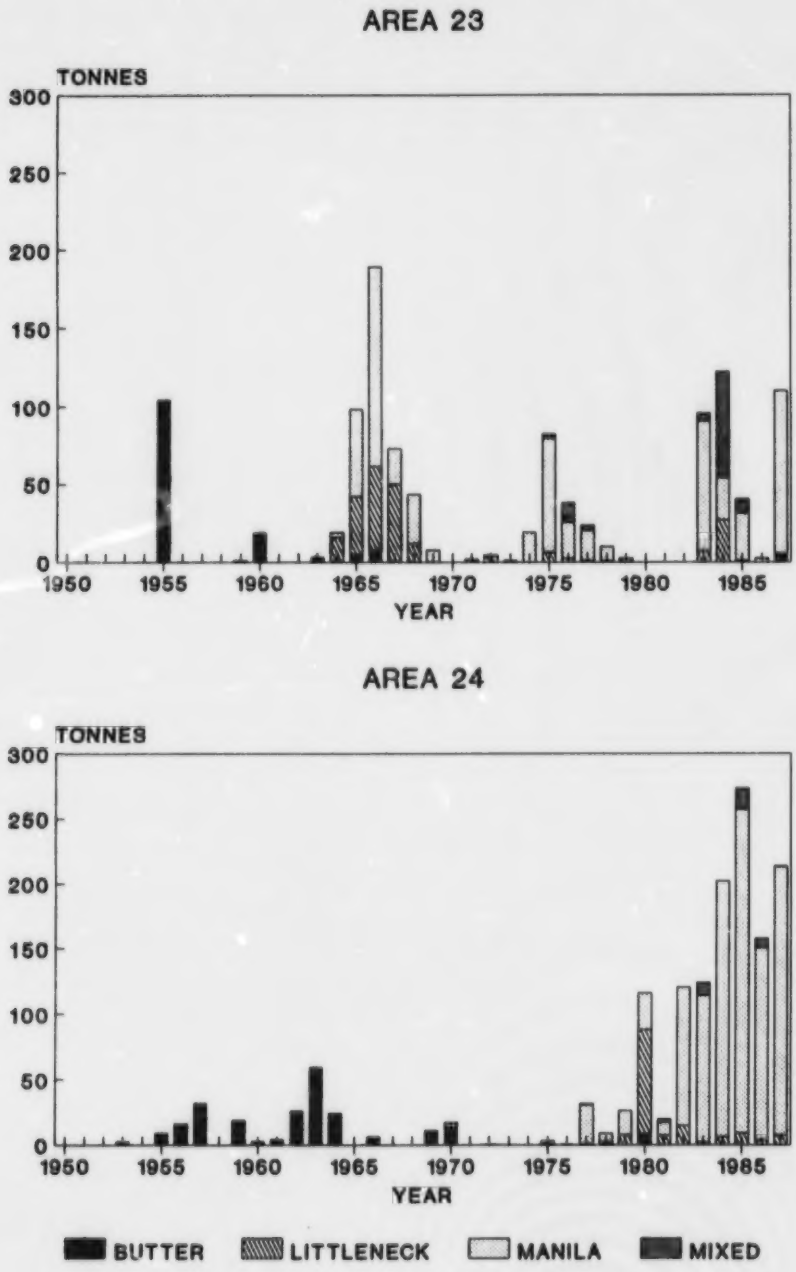

Figure 3. Annual reported landings (tonnes) of intertidal clams from Area 23 and Area 24; 1951 to 1987.

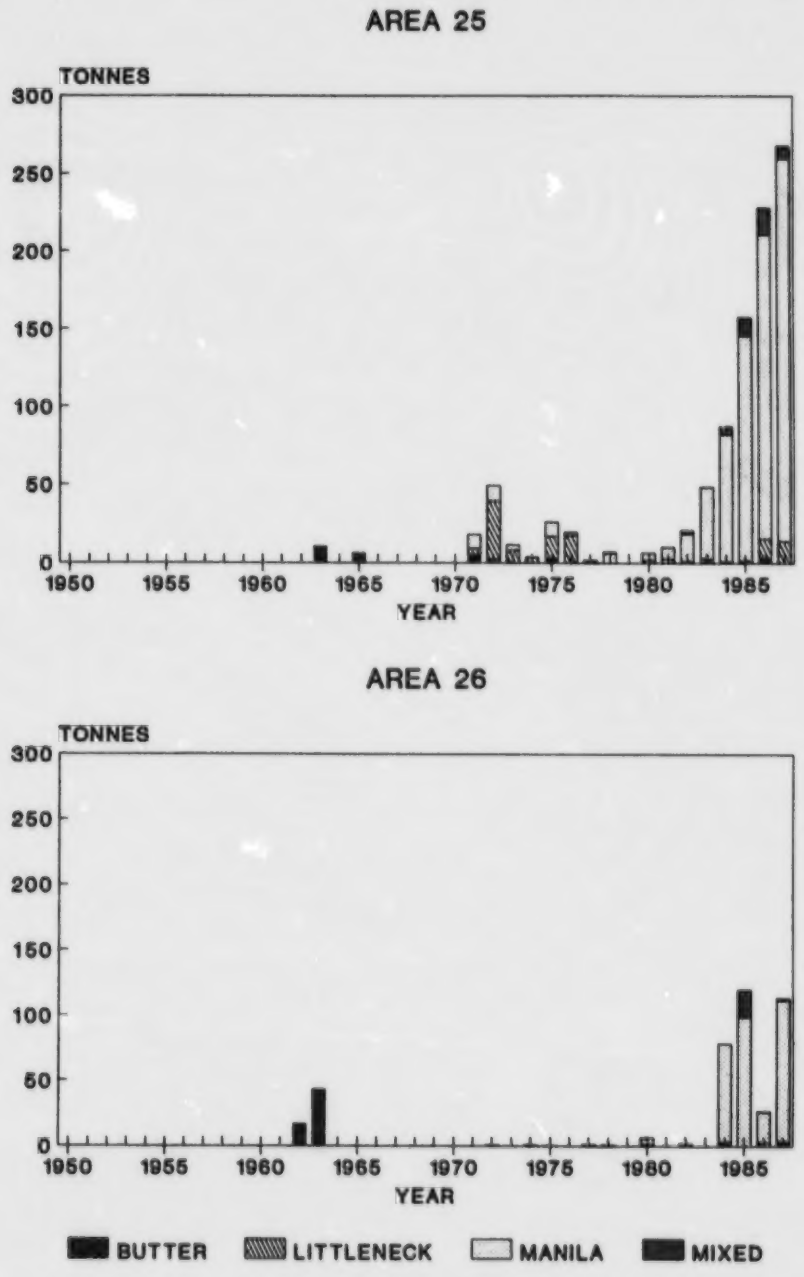

Figure 4. Annual reported landings (tonnes) of intertidal clams from Area 25 and Area 26; 1951 to 1987.

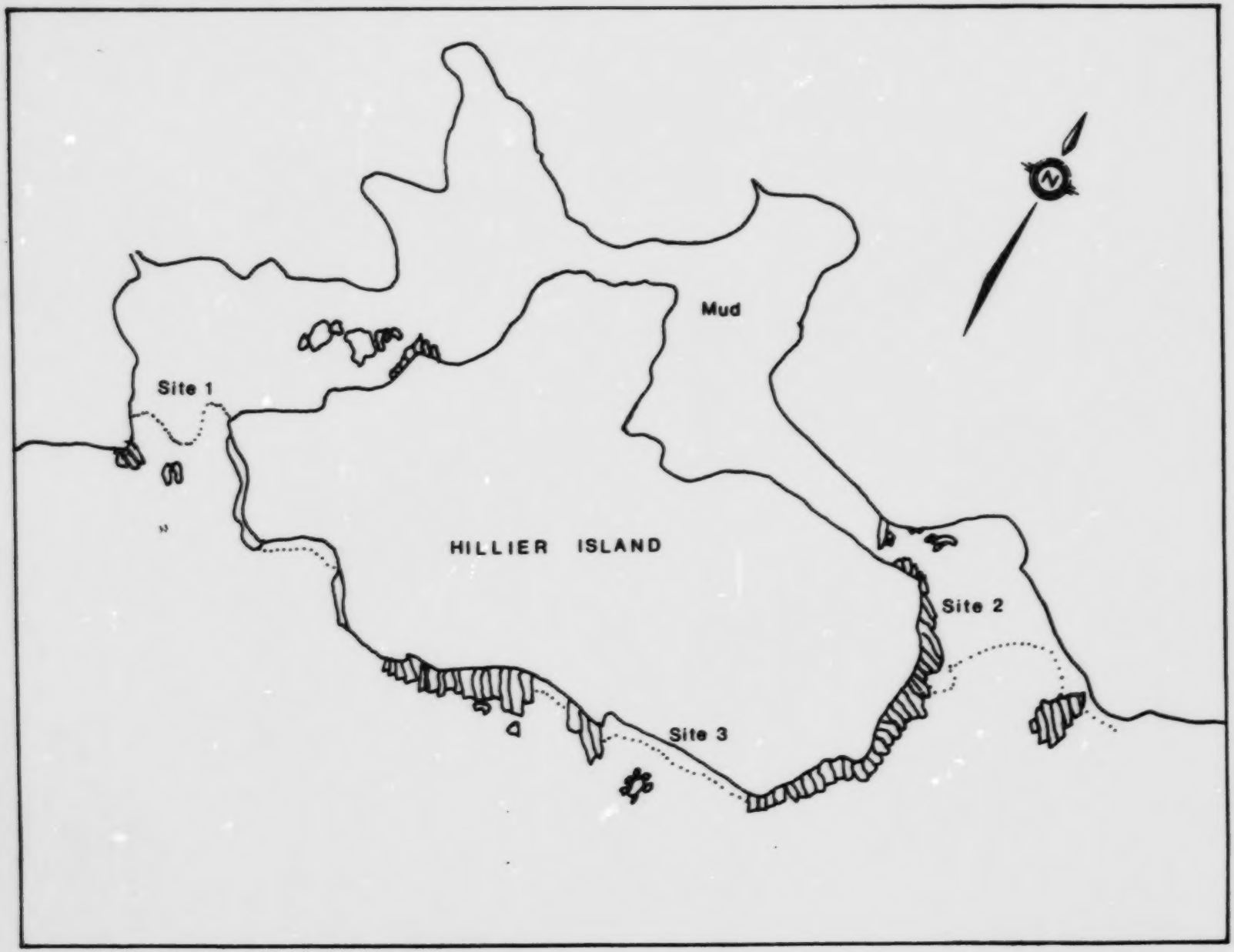

Figure 5. Hillier Island sample sites 1, 2 and 3.

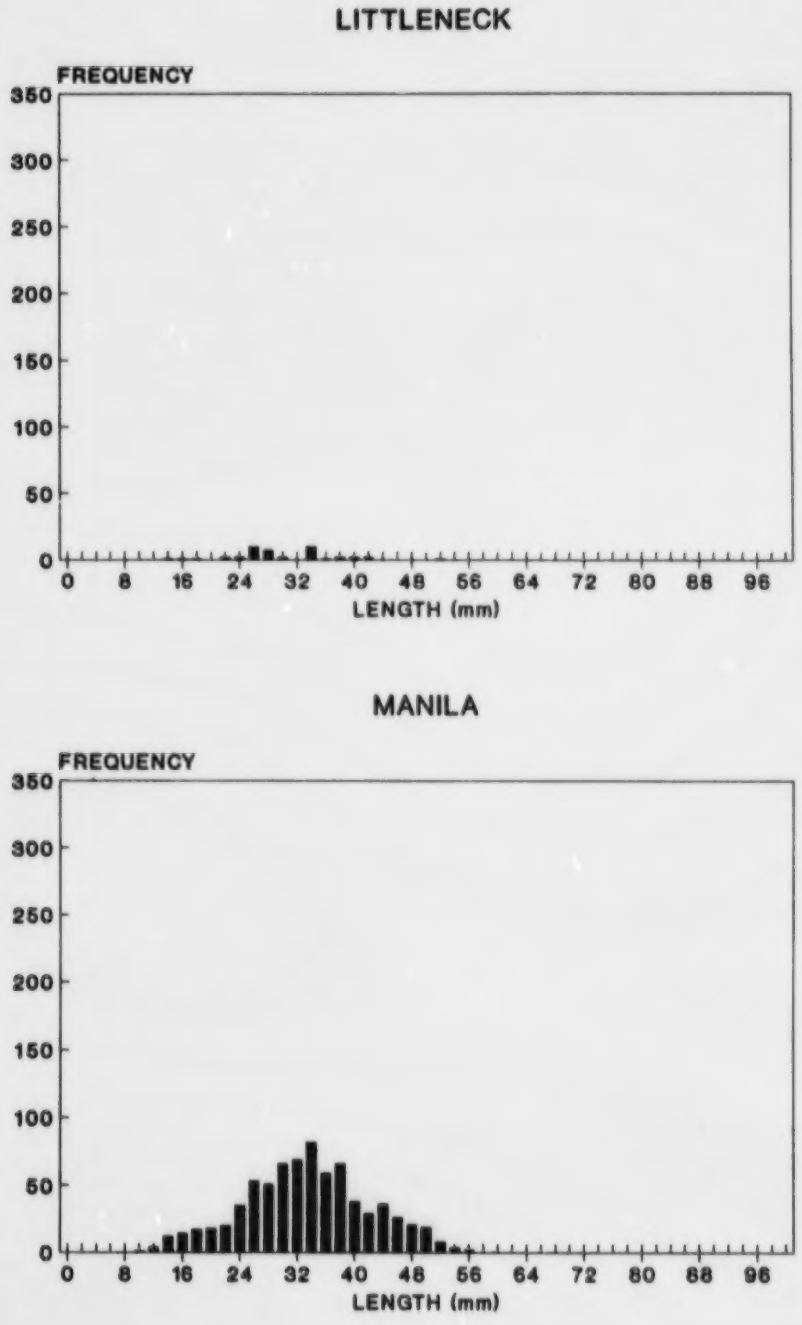

Figure 6. Length frequency distributions of littleneck and manila clams sampled at Hillier Island, November 1981.

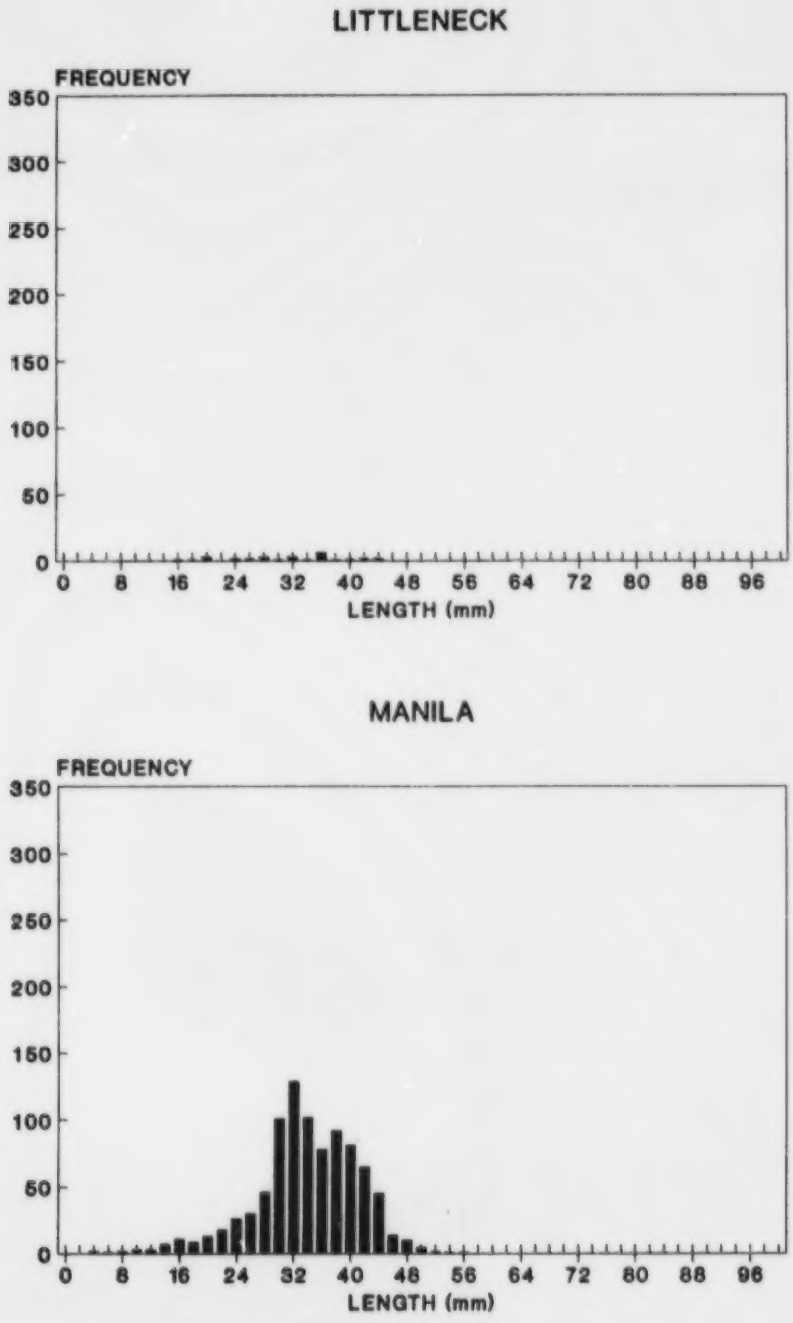

Figure 7. Length frequency distributions of littleneck and manila clams sampled at Hillier Island, February 1983.

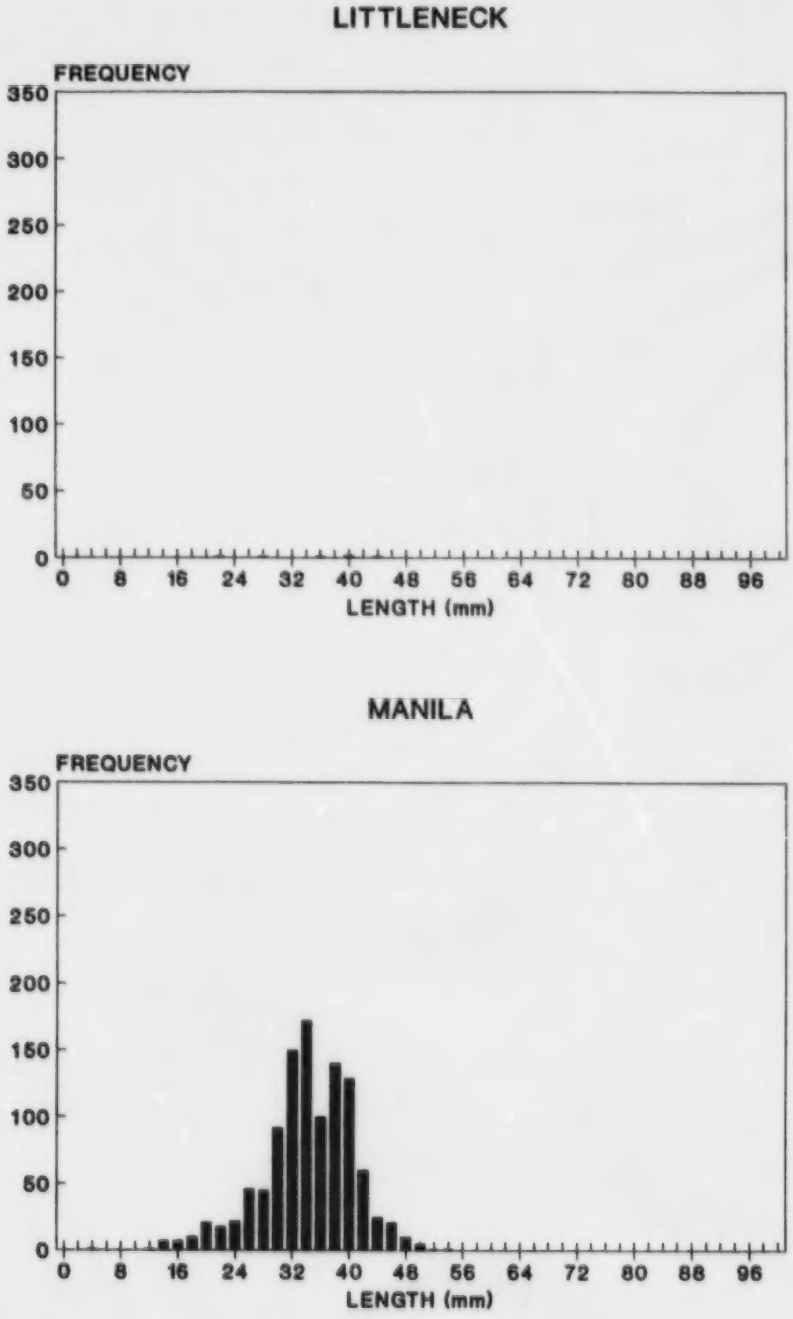

Figure 8. Length frequency distributions of littleneck and manila clams sampled at Hillier Island, February 1984.

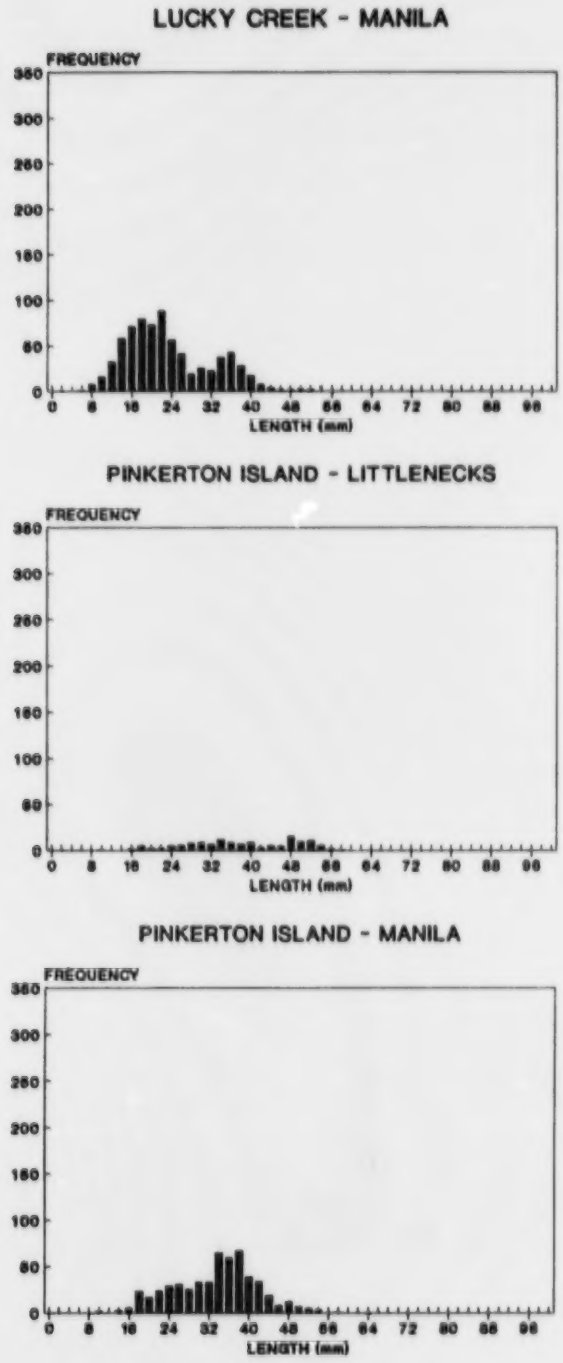

Figure 9. Length frequency distributions of littleneck and manila clams sampled at Lucky Creek and Pinkerton Island, February 1983.

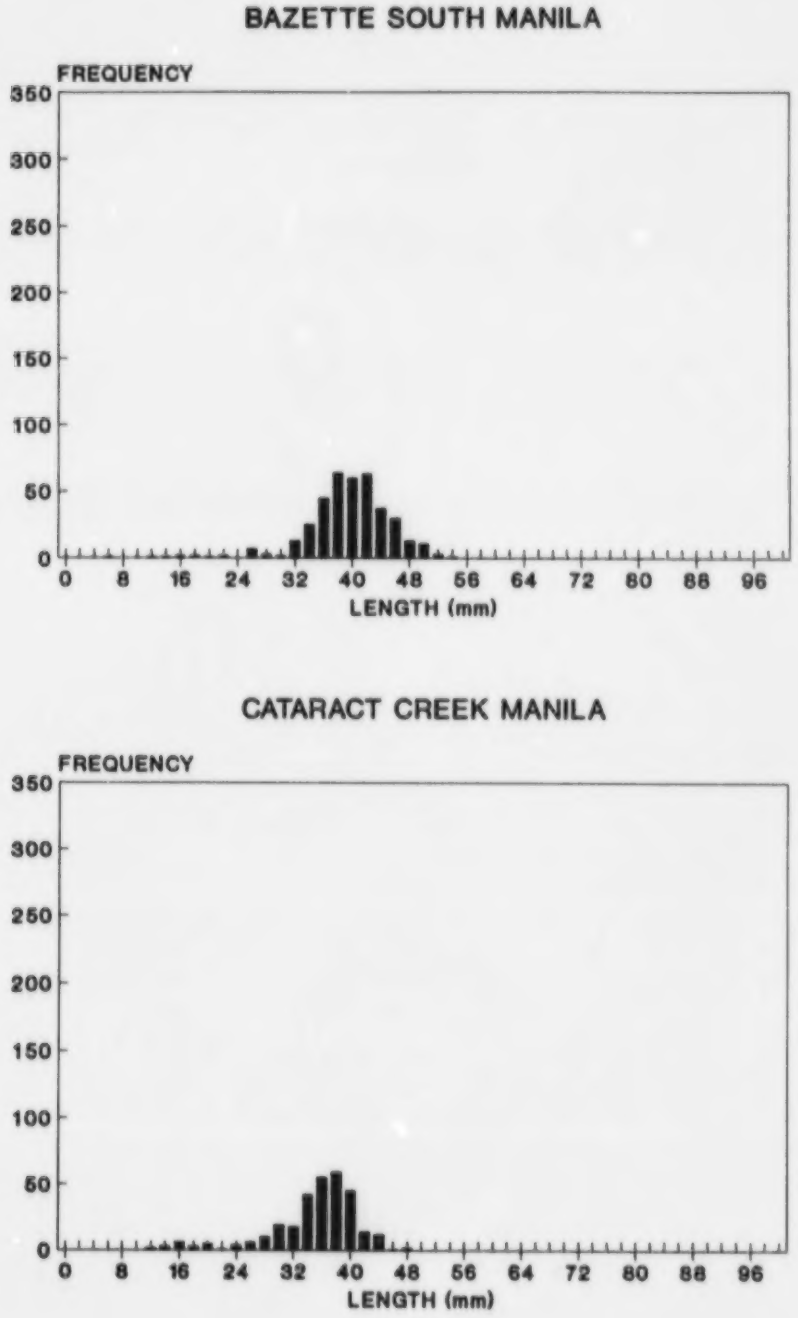

Figure 10. Length frequency distributions of littleneck and manila clams sampled at Bazette Island and Cataract Creek, February 1983.

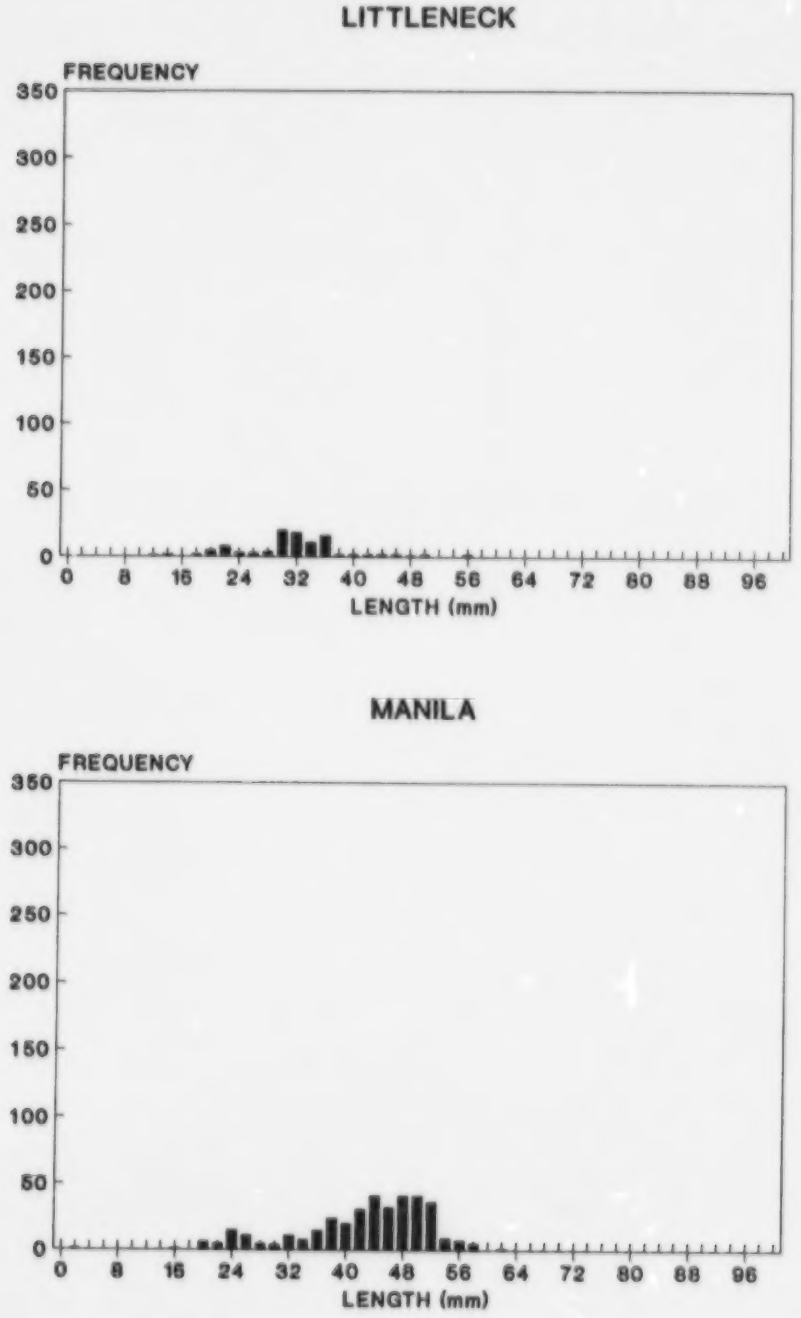

Figure 11. Length frequency distributions of littleneck and manila clams sampled at Useless Inlet, February 1983.

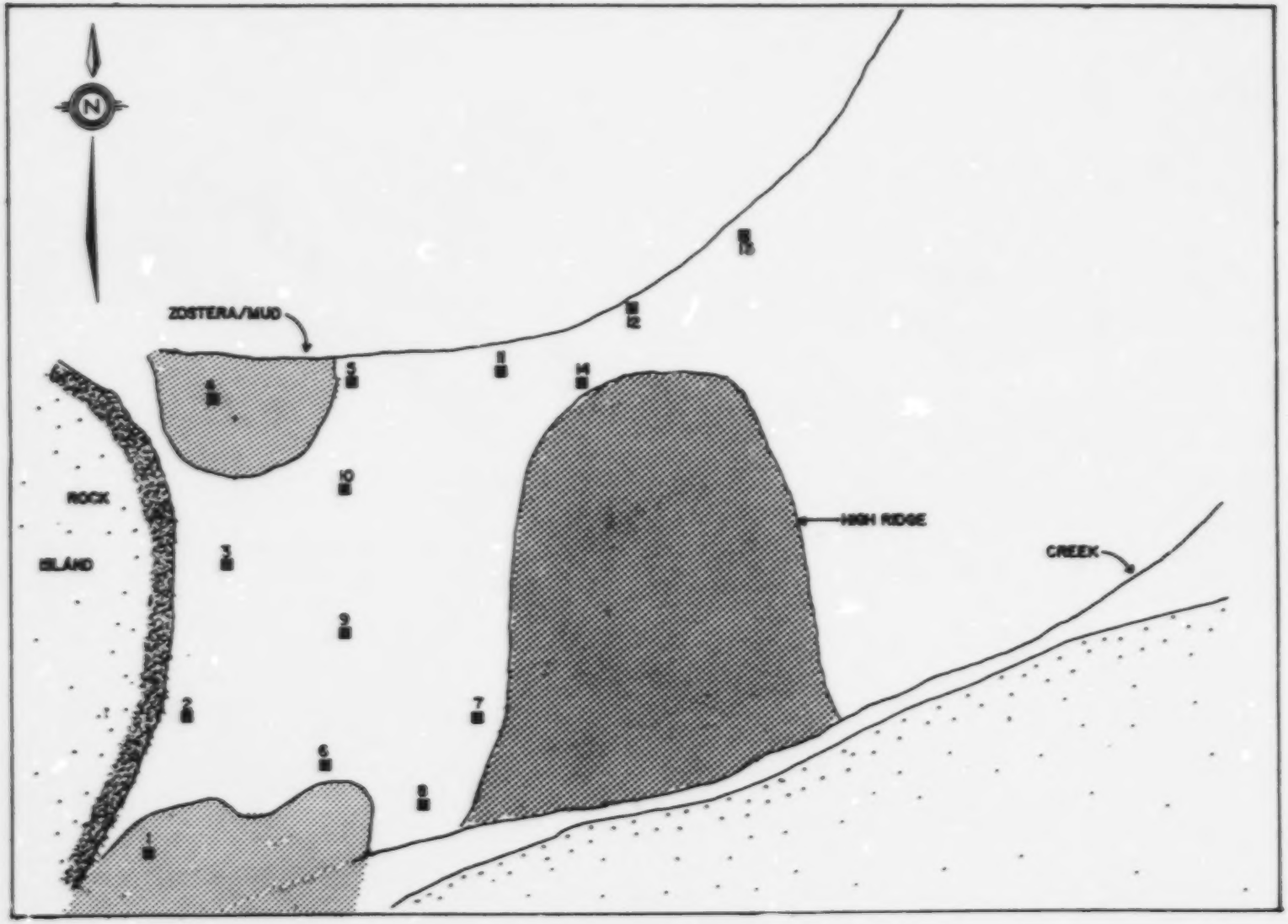

Figure 12. Location of sample plots at Atleo River.

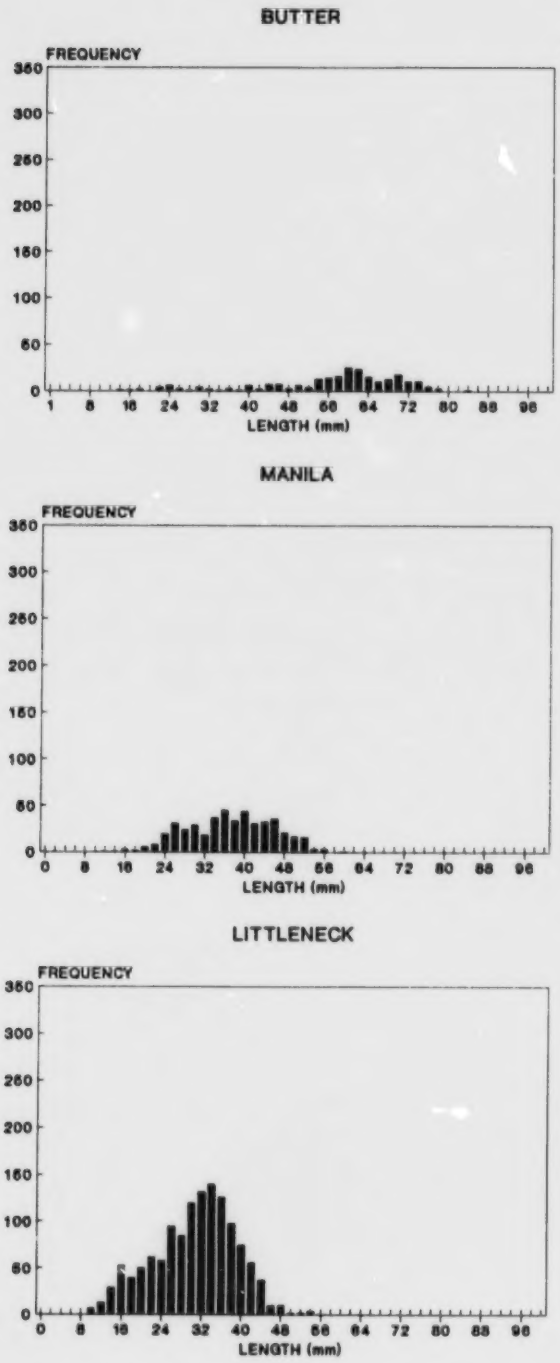

Figure 13. Length frequency distributions of butter, littleneck and manila clams at Atleo River, July 1983.

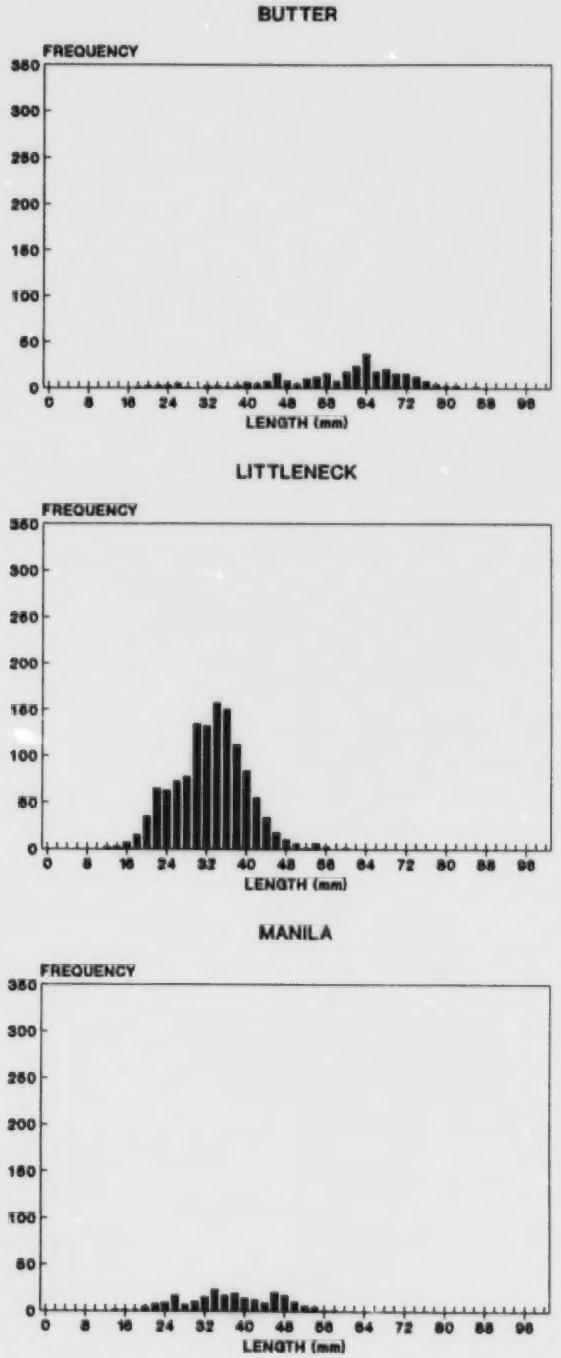

Figure 14. Length frequency distributions of butter, littleneck and manila clams at Atleo River, July 1984.

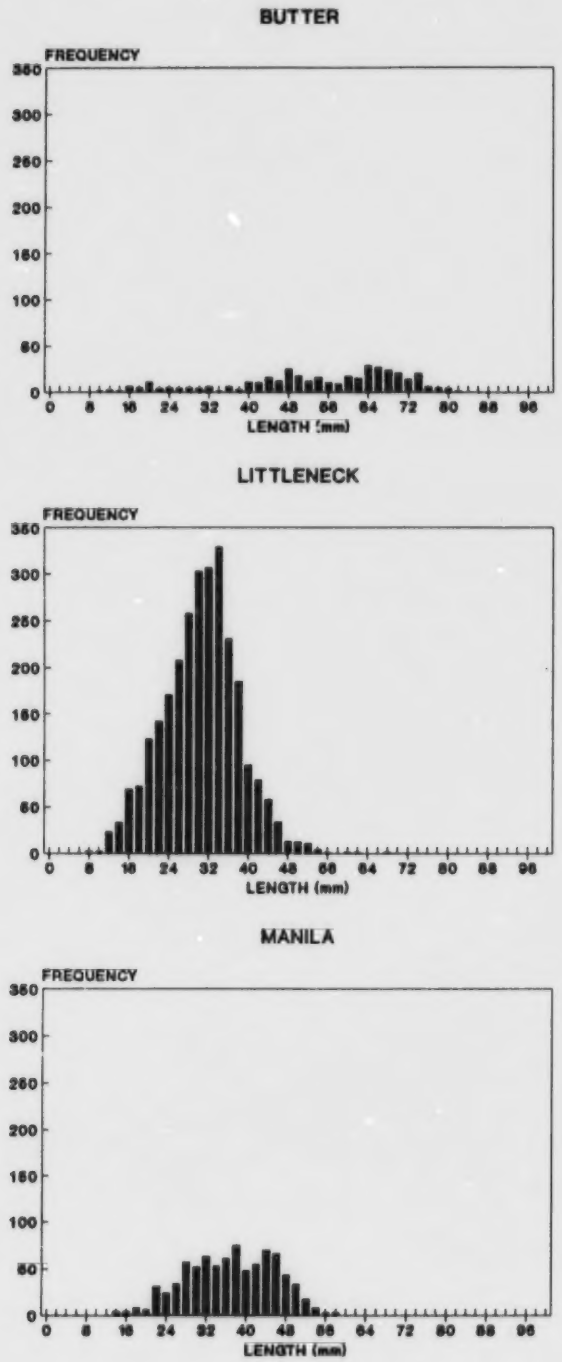

Figure 15. Length frequency distributions of butter, littleneck and manila clams at Atleo River, July 1985.

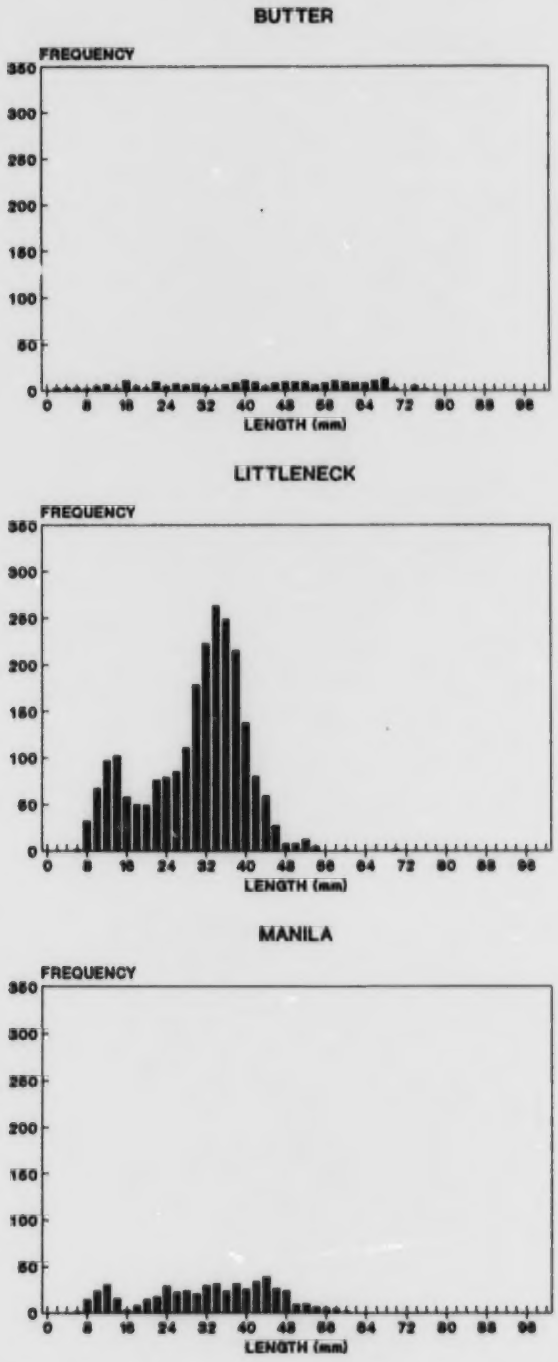

Figure 16. Length frequency distribution of littleneck manila and butter clams from Atleo River, July 1986.

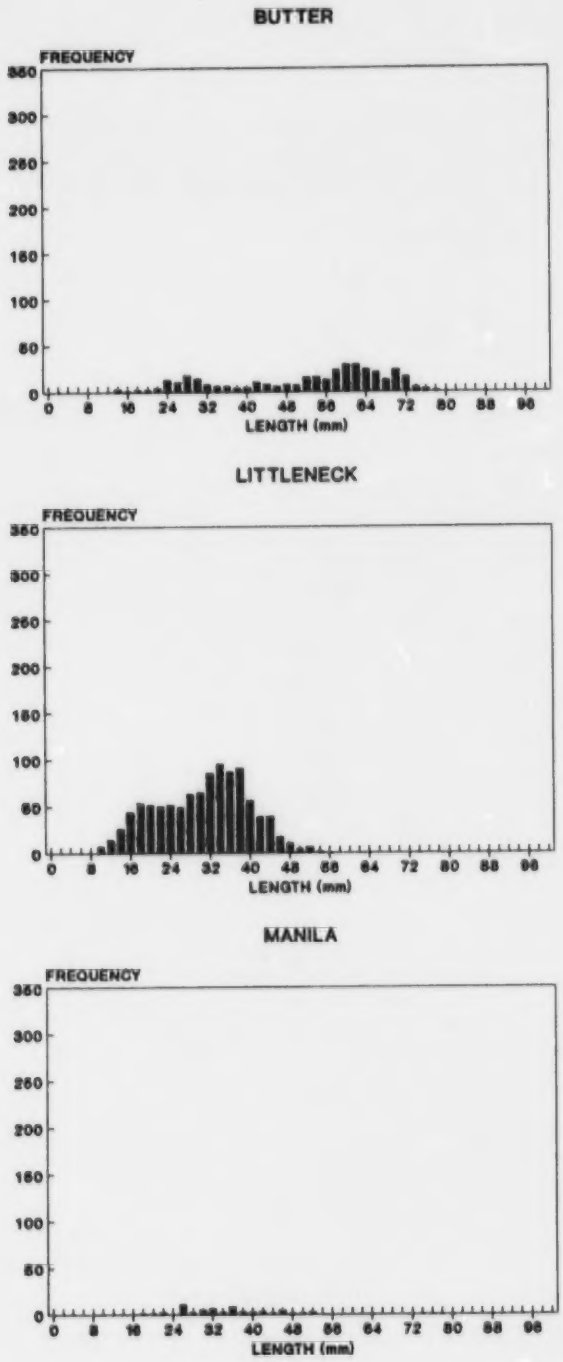

Figure 17. Length frequency distribution of littleneck manila and butter clams from Atleo River, July 1987.

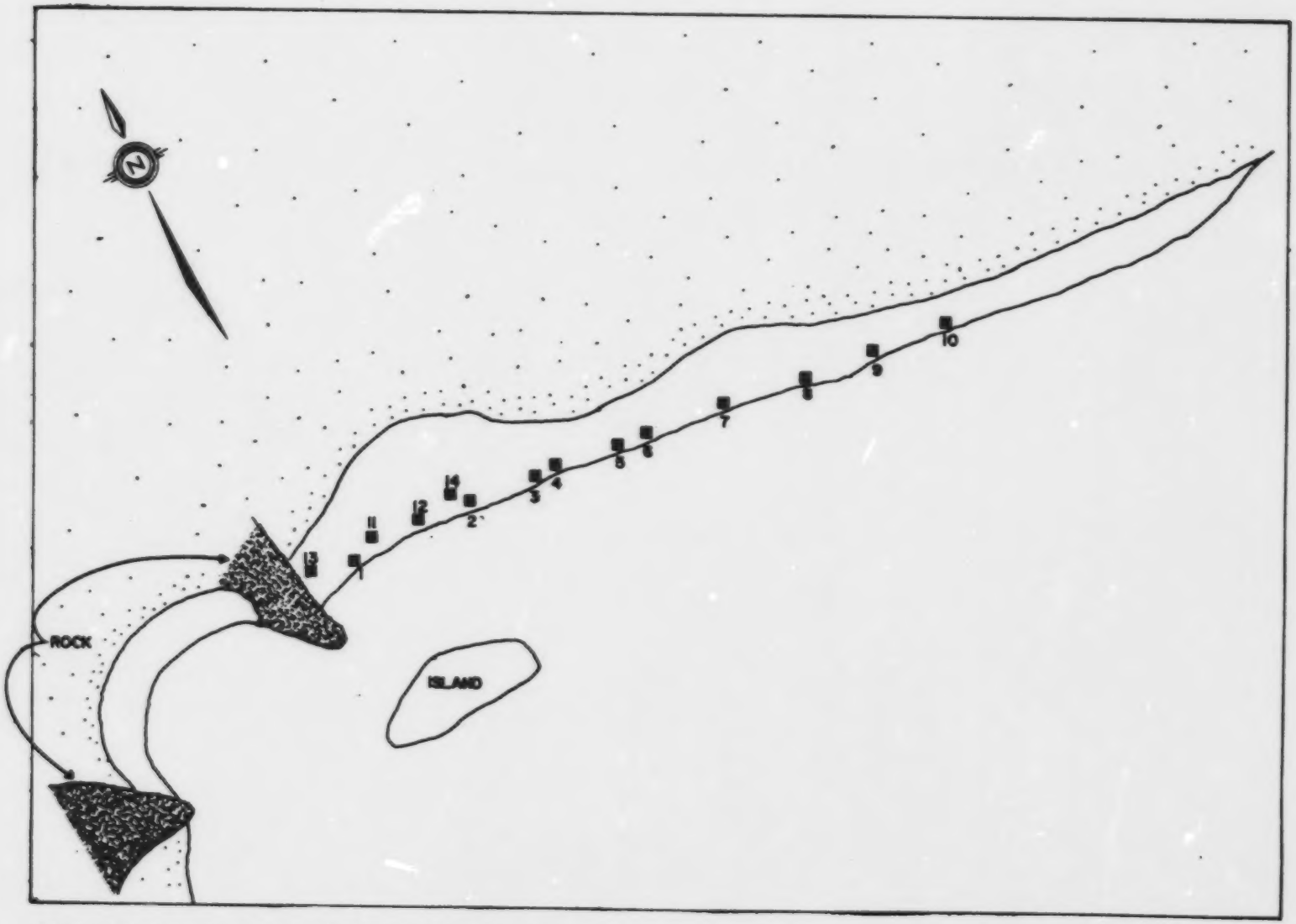

Figure 18. Location of sample plots at Whiskey Jenny.

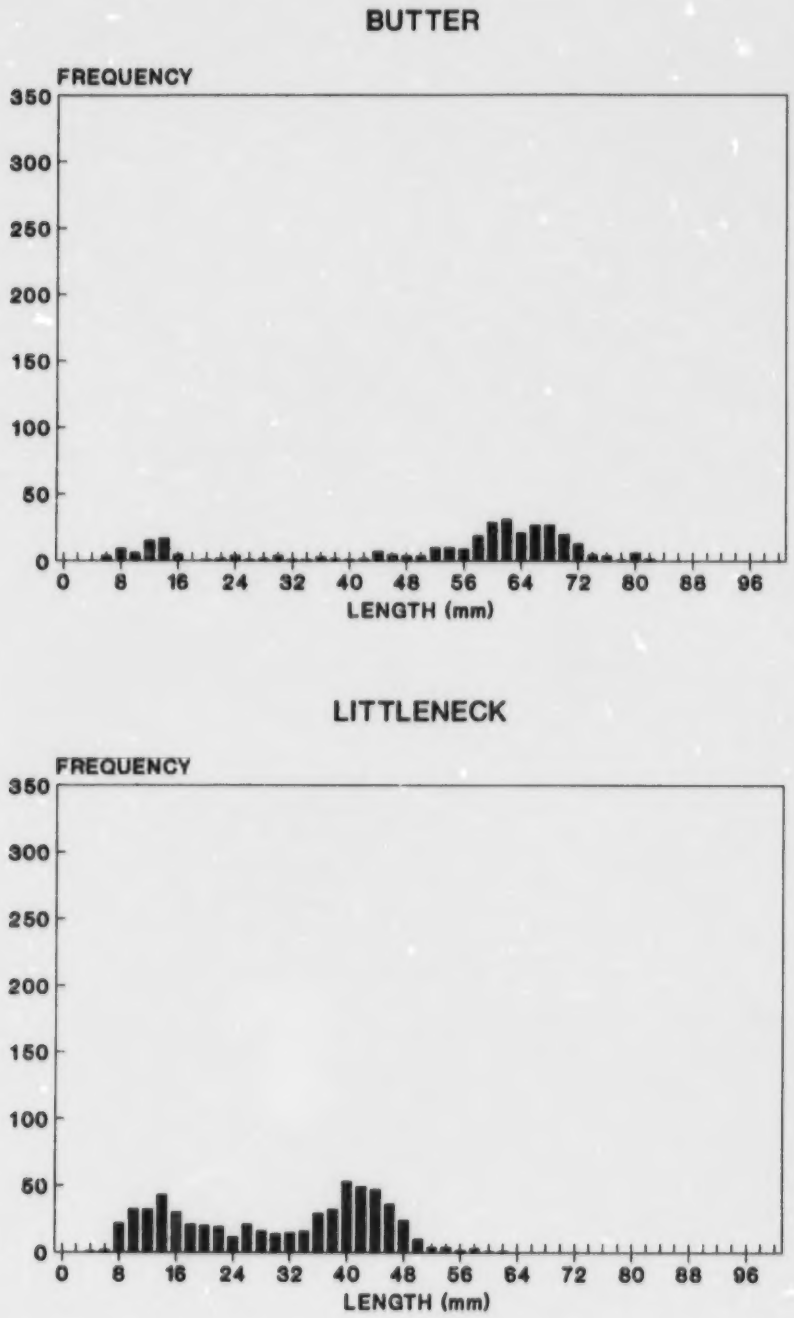

Figure 19. Length frequency distributions of butter, littleneck and manila clams at Whiskey Jenny, July 1983.

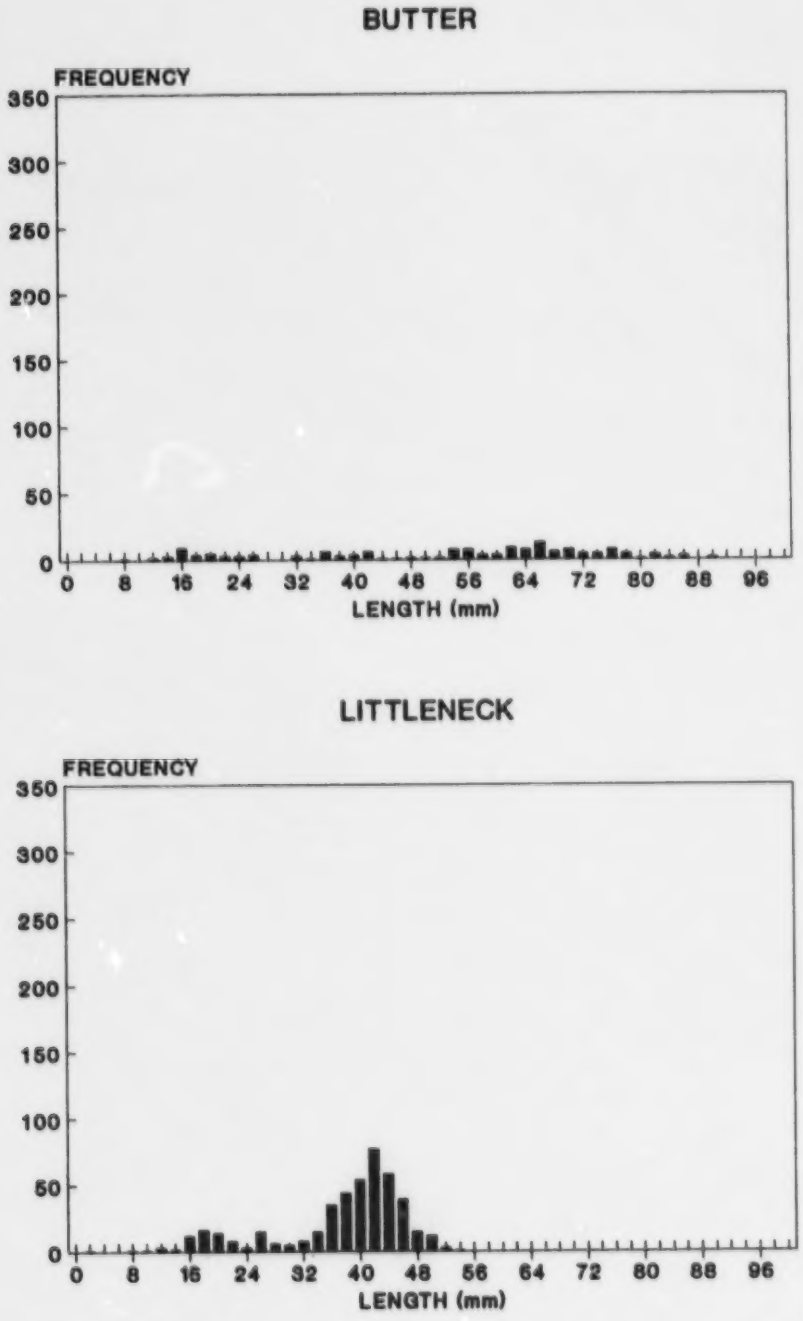

Figure 20. Length frequency distributions of butter and littleneck clams at Whiskey Jenny, July 1984.

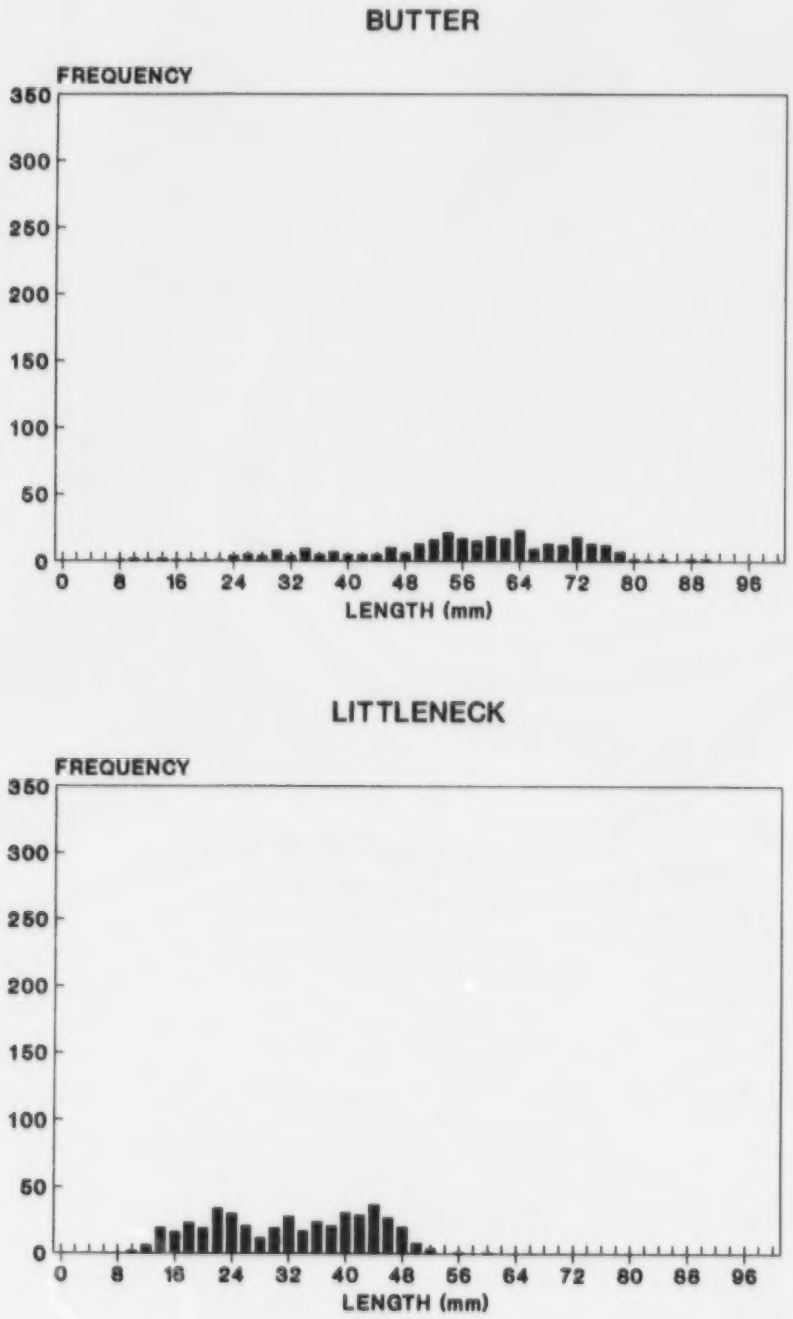

Figure 21. Length frequency distributions of butter, littleneck and manila clams at Whiskey Jenny, July 1985.

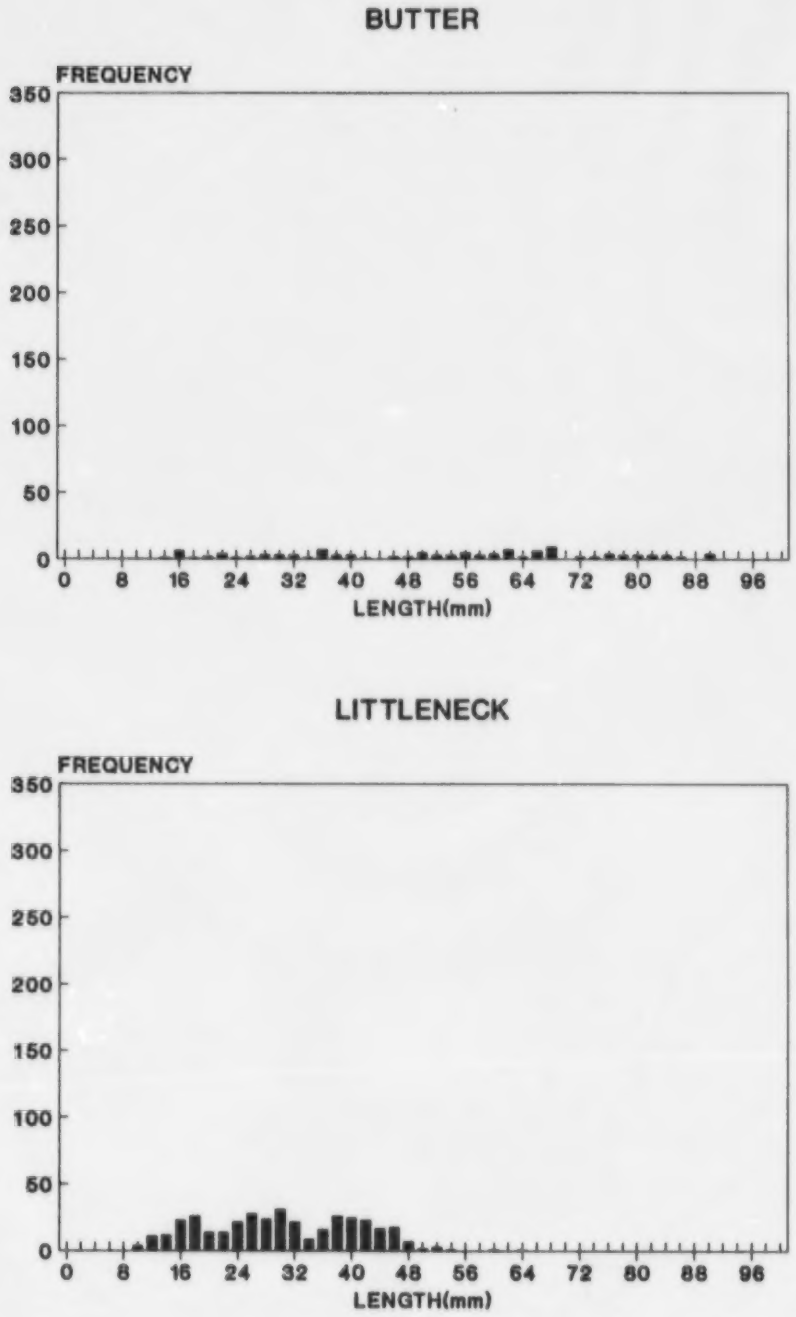

Figure 22. Length frequency distributions of littleneck and butter clams from Whiskey Jenny, July 1987.

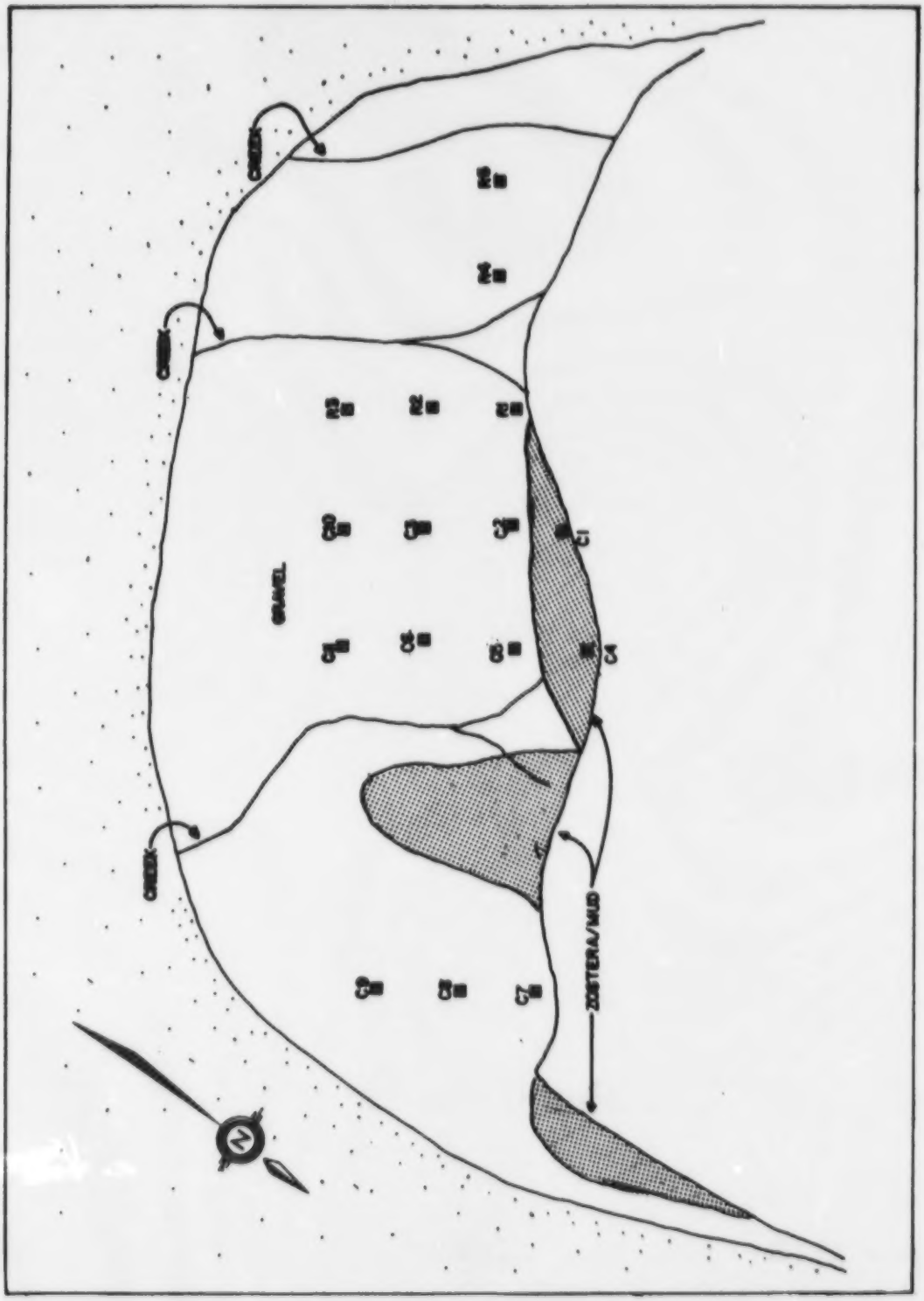

Figure 23. Location of sample plots at Whitepine Cove.

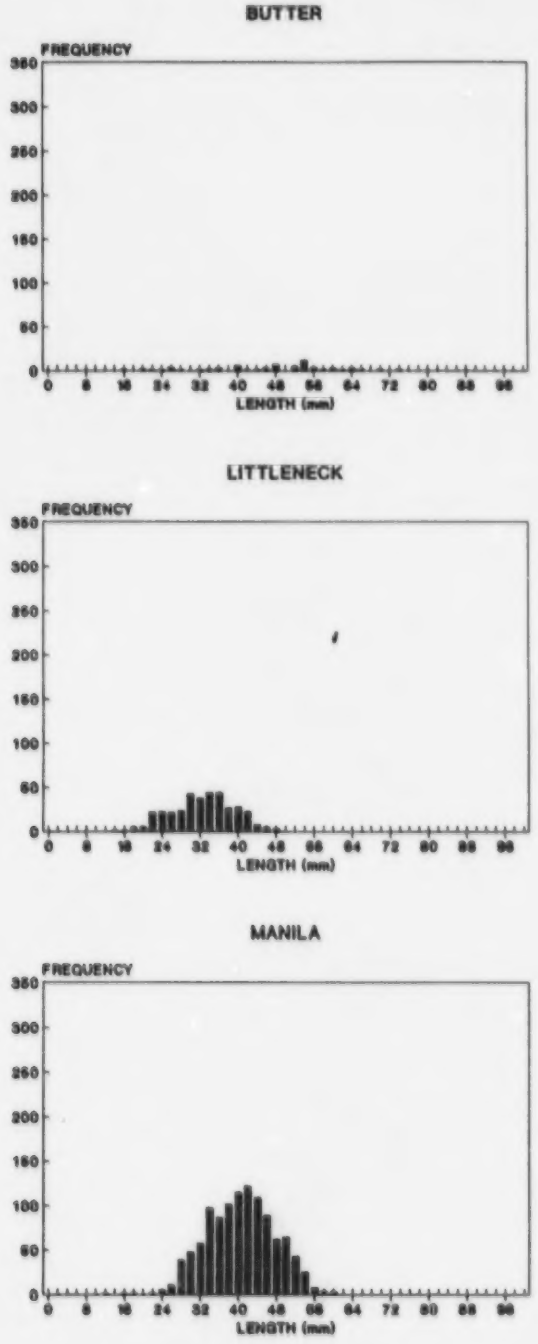

Figure 24. Length frequency distributions of butter, littleneck and manila clams at Whitepine Cove, June 1981.

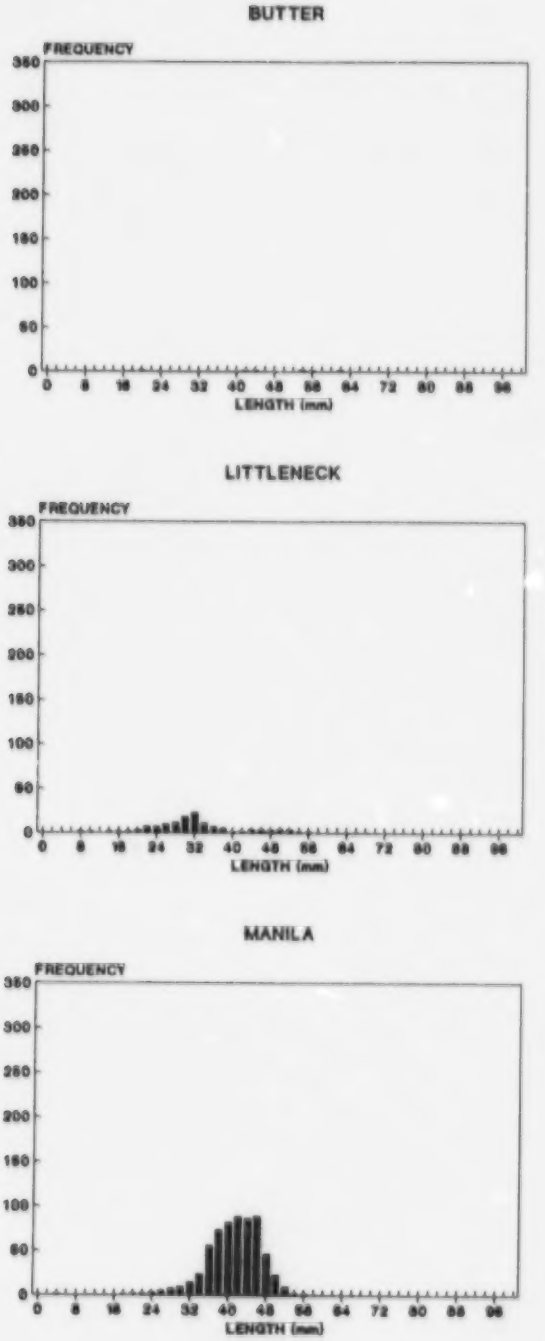

Figure 25. Length frequency distributions of butter, littleneck and manila clams at Whitepine Cove, July 1984.

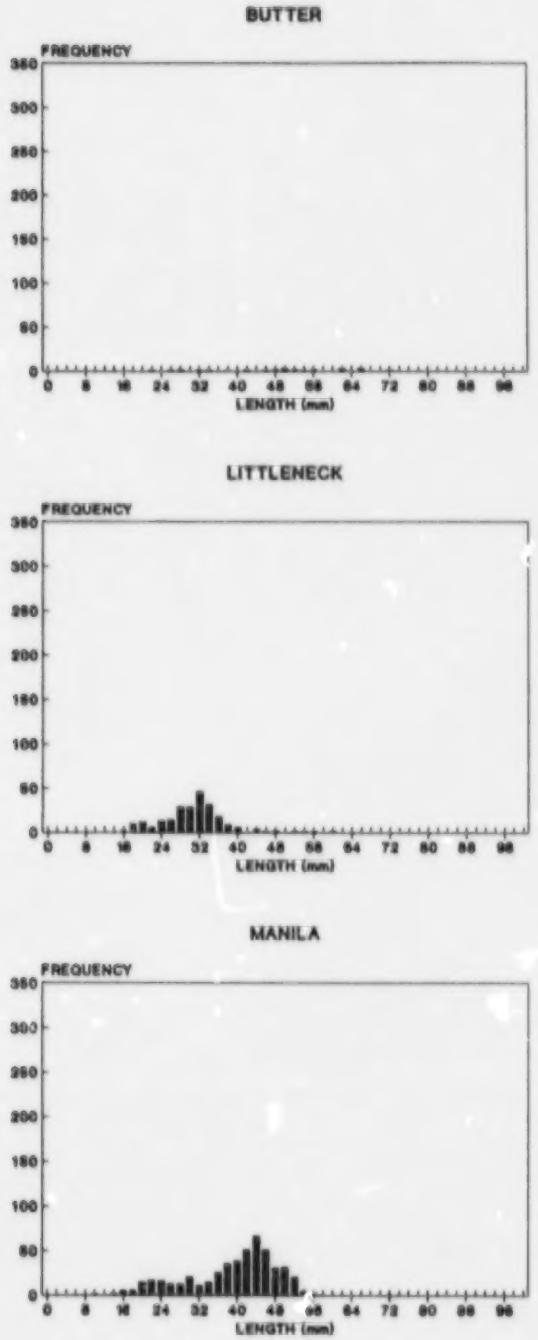

Figure 26. Length frequency distributions of butter, littleneck and manila clams at Whitepine Cove, July 1985.

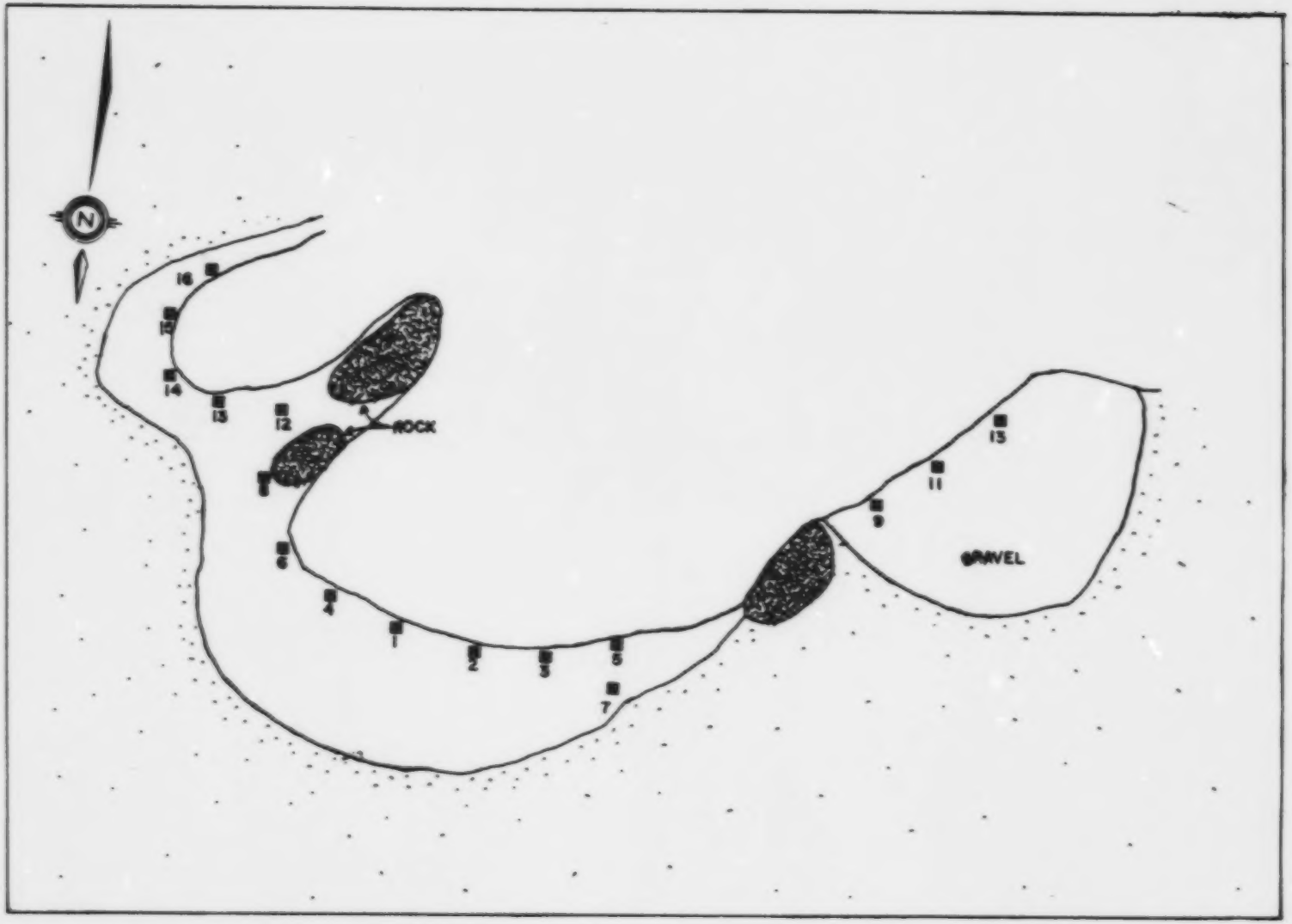

Figure 27. Location of sample plots at Warn Bay.

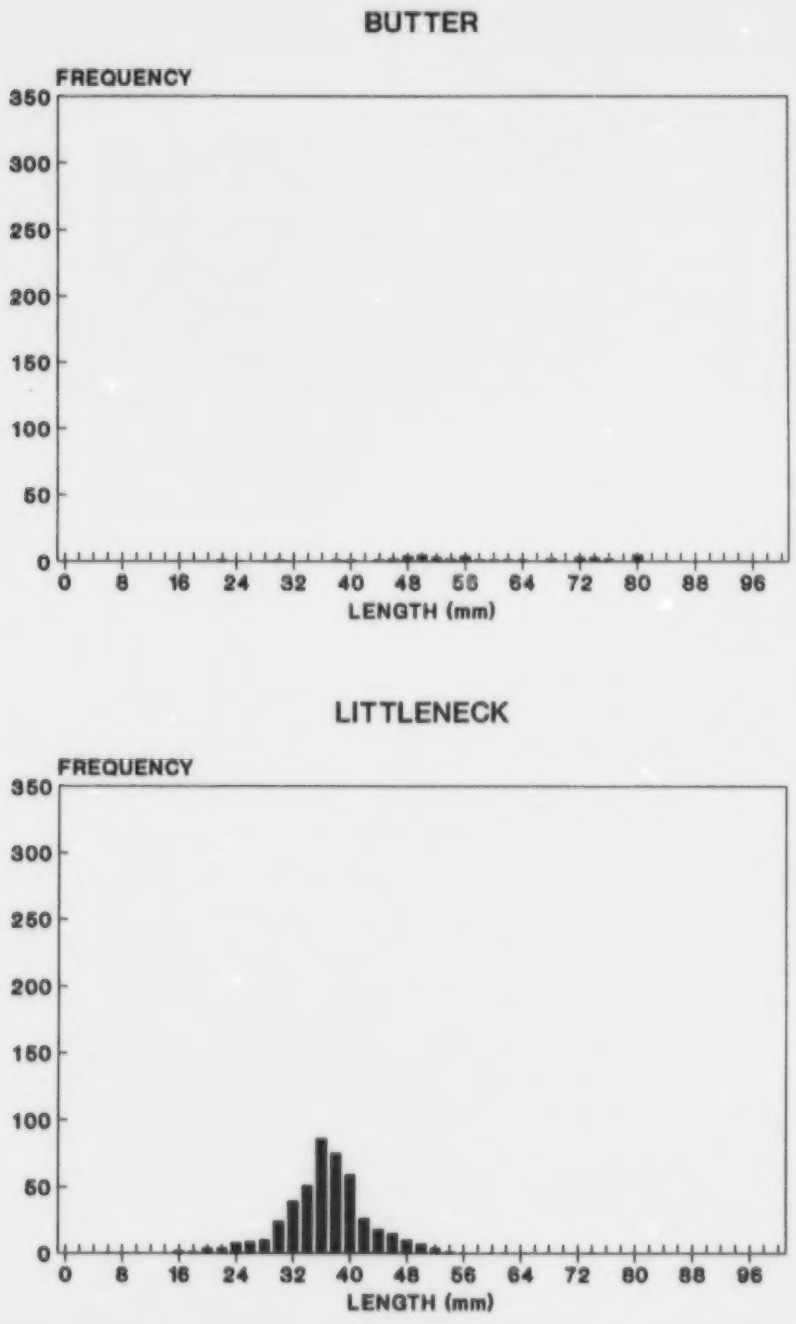

Figure 28. Length frequency distributions of butter and littleneck clams at Warn Bay, June 1981.

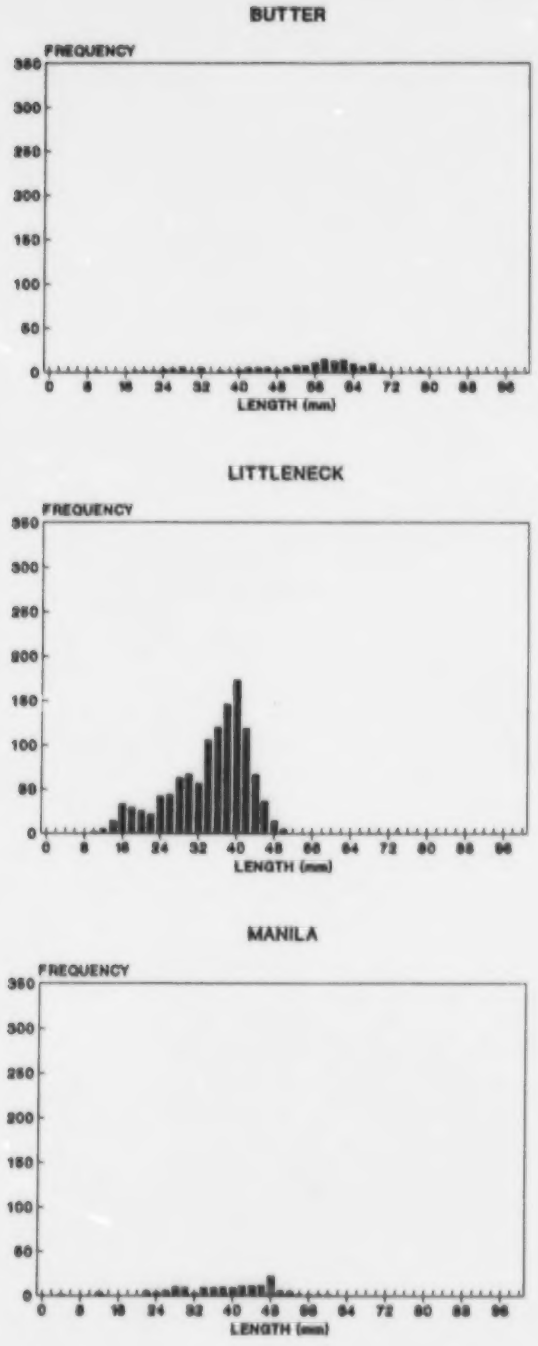

Figure 29. Length frequency distributions of butter, littleneck and manila clams at Warn Bay, July 1984.

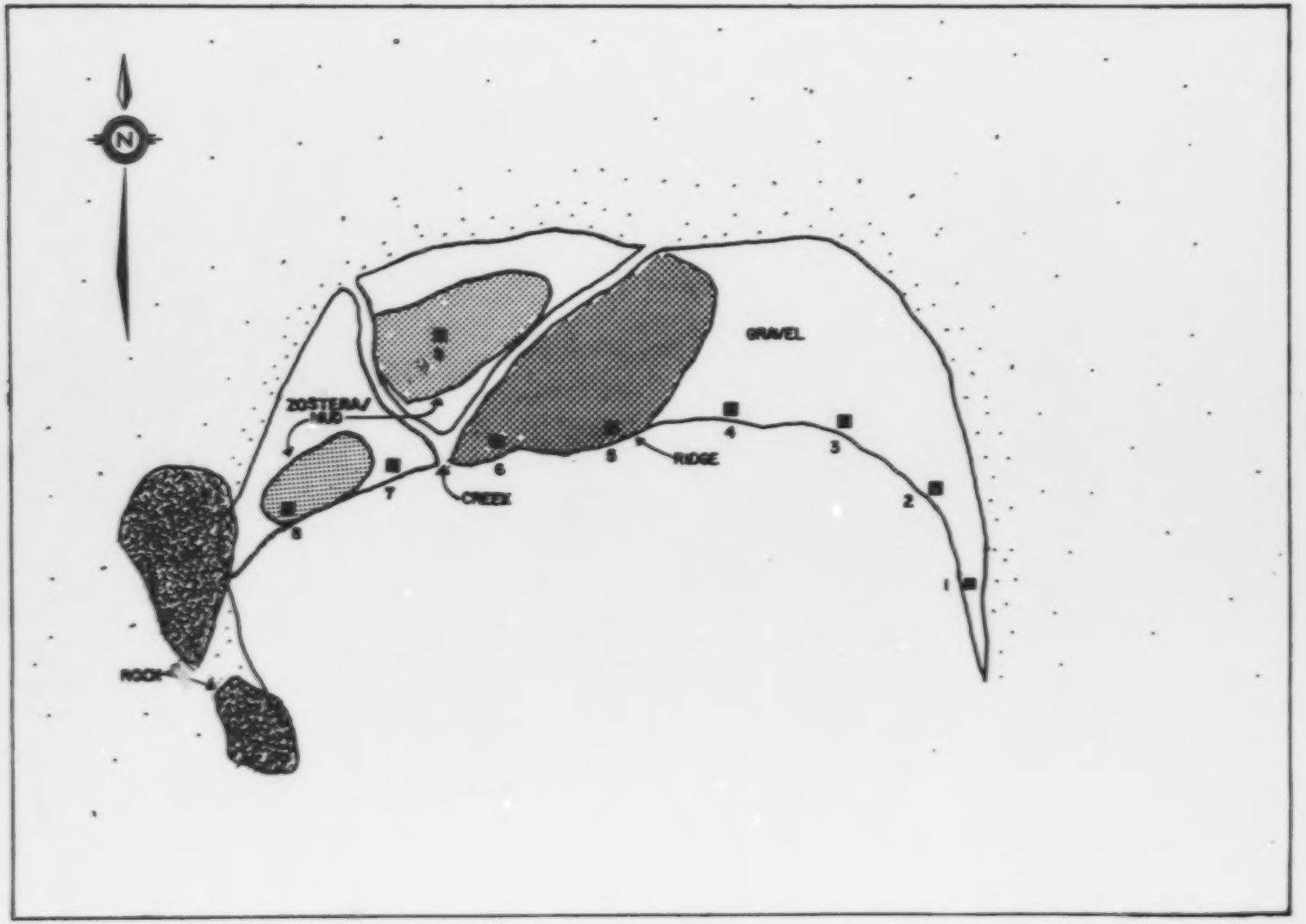

Figure 30. Location of sample plots at Mosquito Harbour.

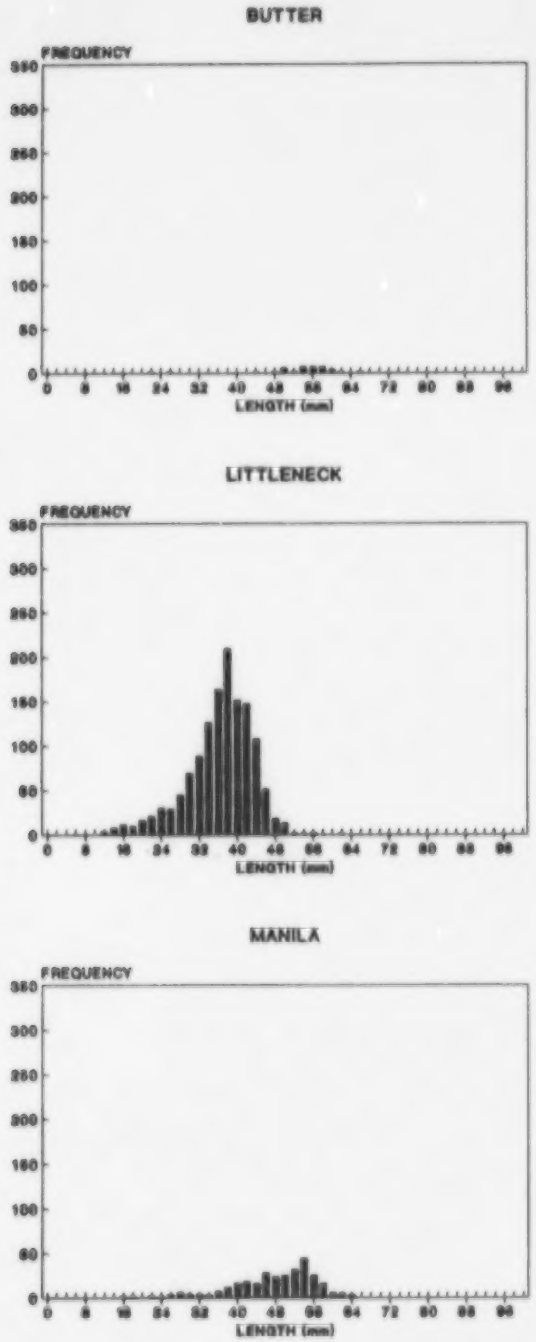

Figure 31. Length frequency distributions of butter, littleneck and manila clams at Mosquito Harbour, July 1984.

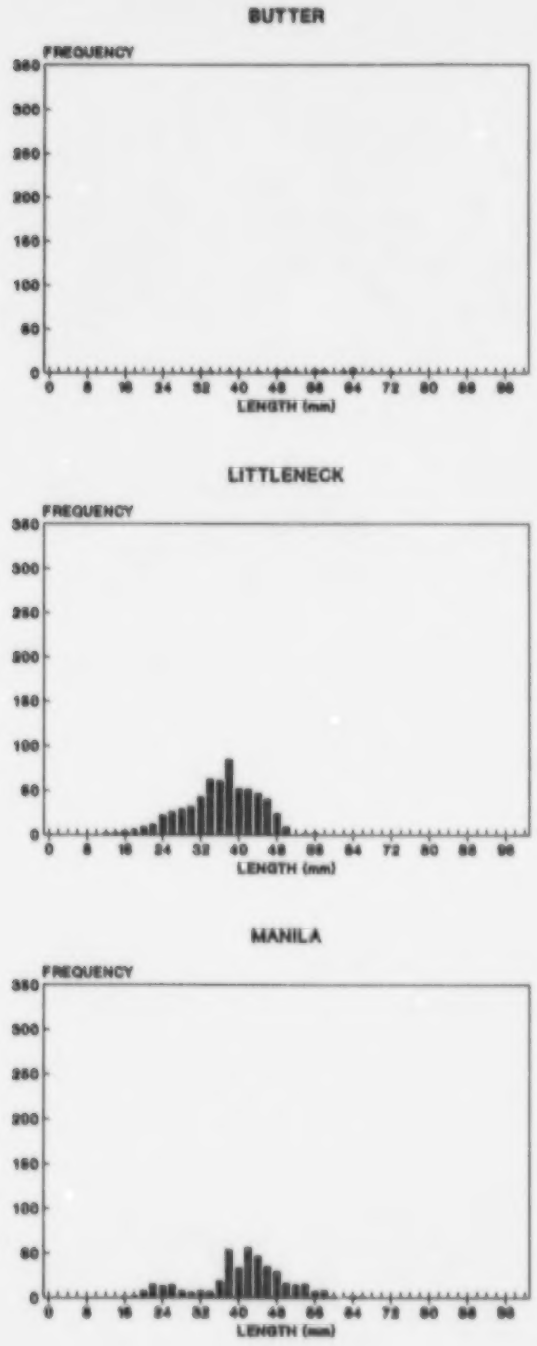

Figure 32. Length frequency distributions of butter, littleneck and manila clams at Mosquito Harbour, July 1985.

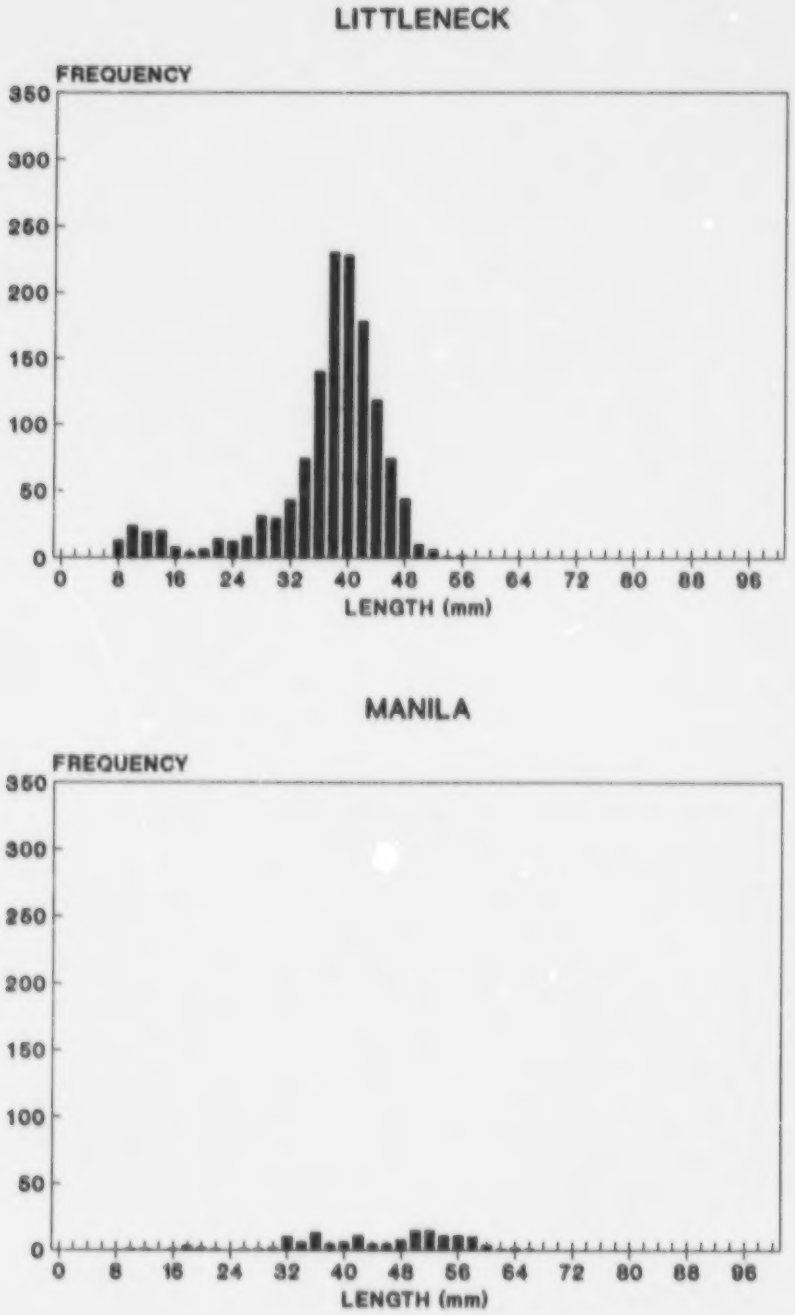

Figure 33. Length frequency distributions of littleneck and manila clams from Mosquito Harbour, July 1986.

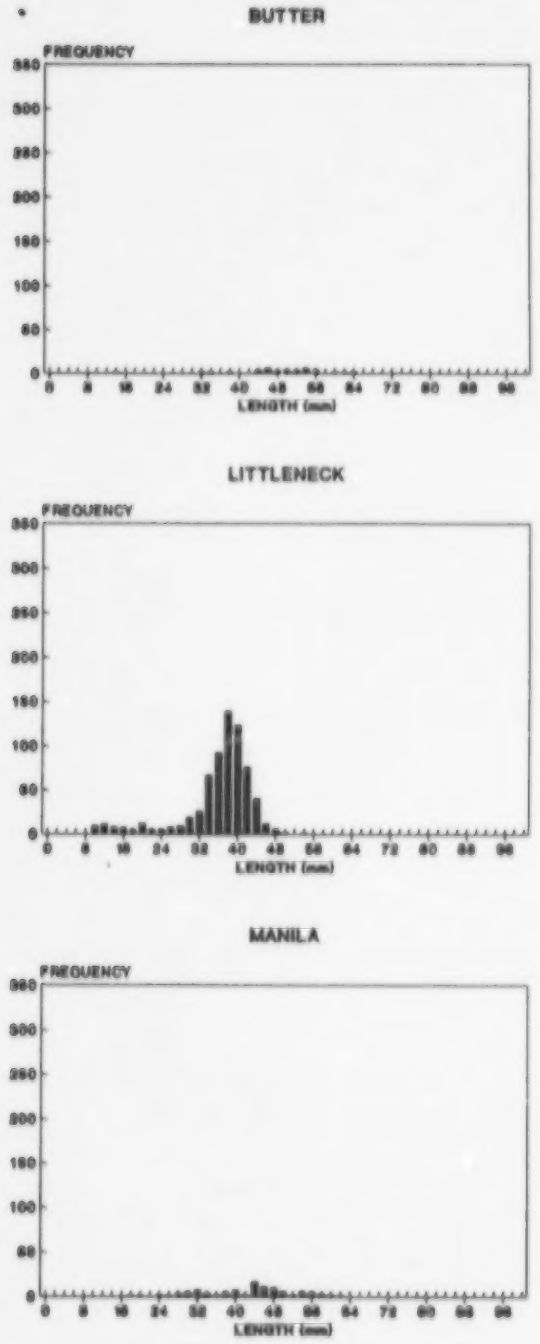

Figure 34. Length frequency distributions of littleneck, manila and butter clams from Mosquito Harbour, July 1987.

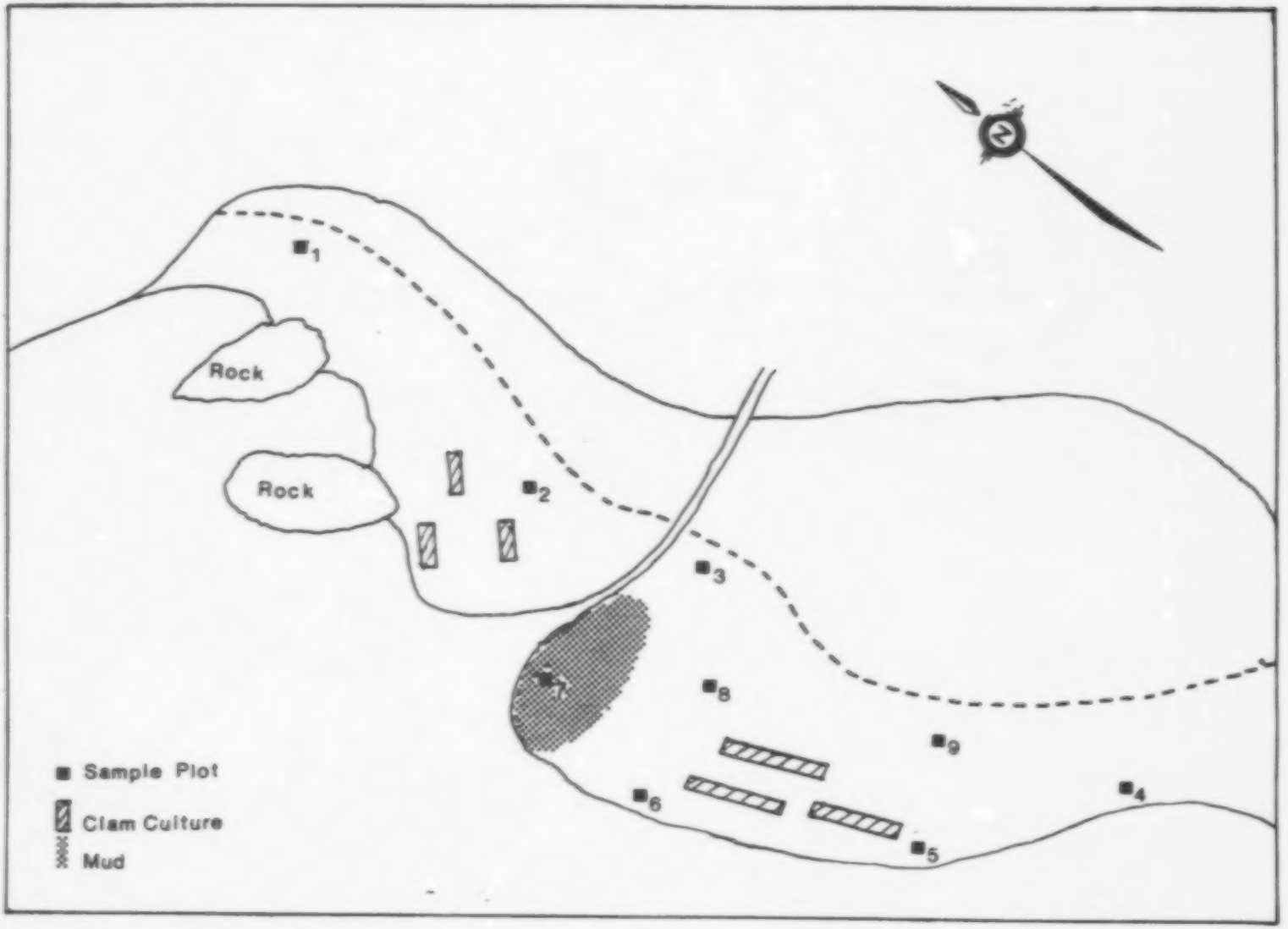

Figure 35. Location of sample plots at Sulphur Passage, July 1985.

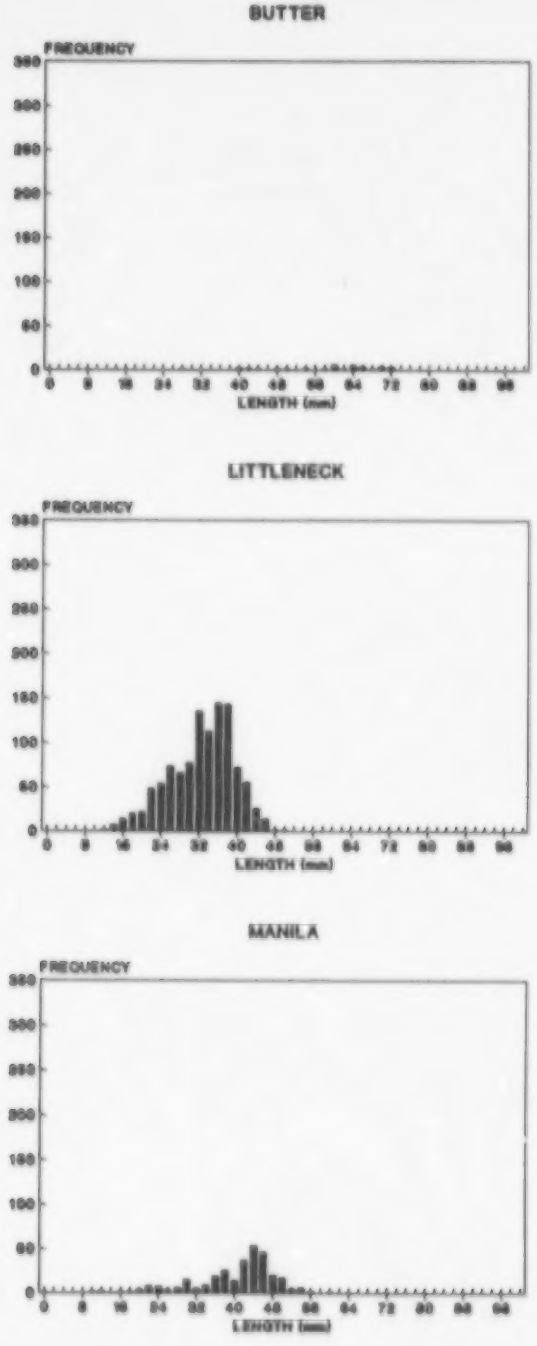

Figure 36. Length frequency distributions of butter, littleneck and manila clams at Sulphur Passage, July 1985.

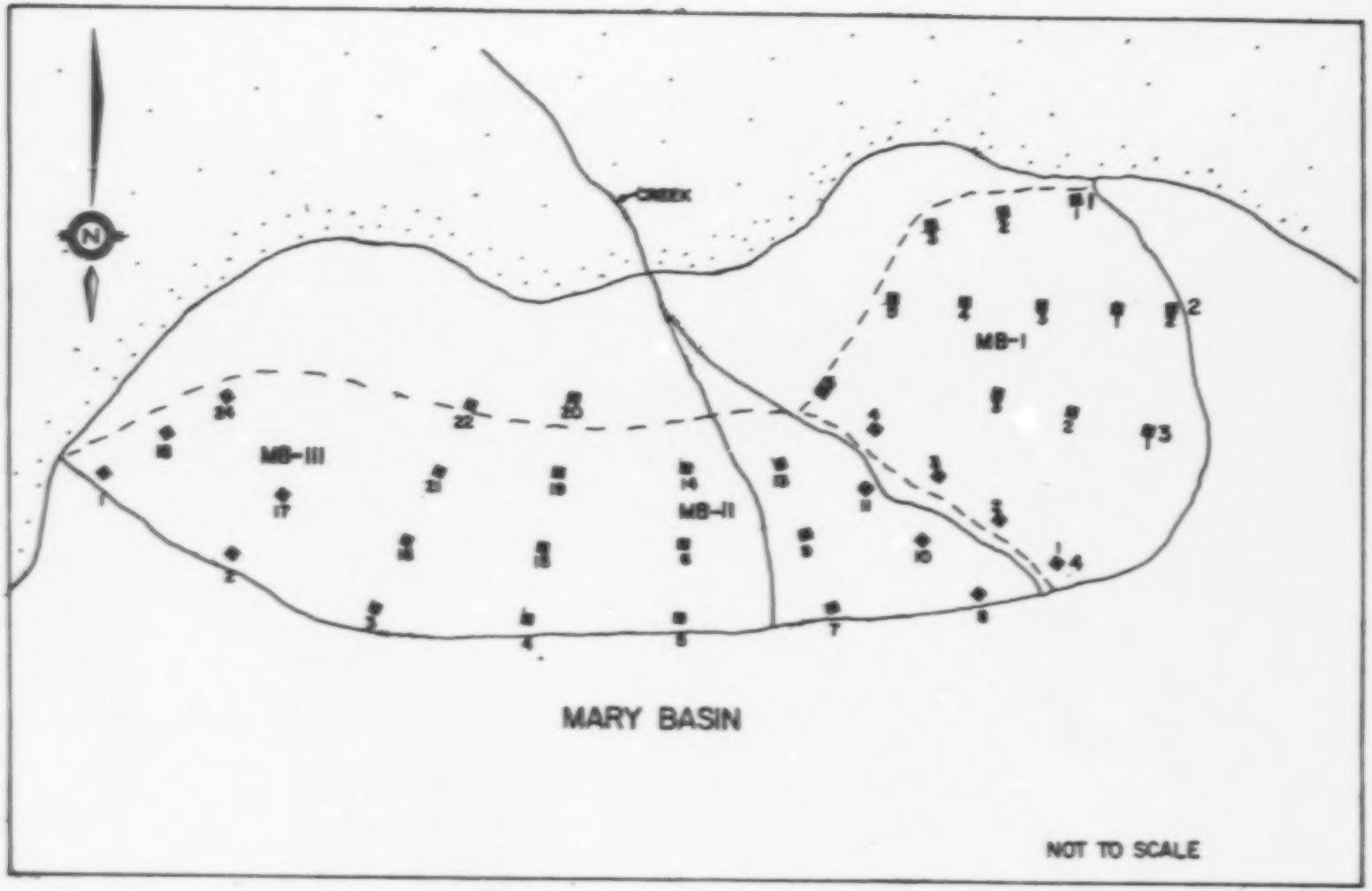

Figure 37. Location of sample plots at Mary Basin - Site 1 August 1984.

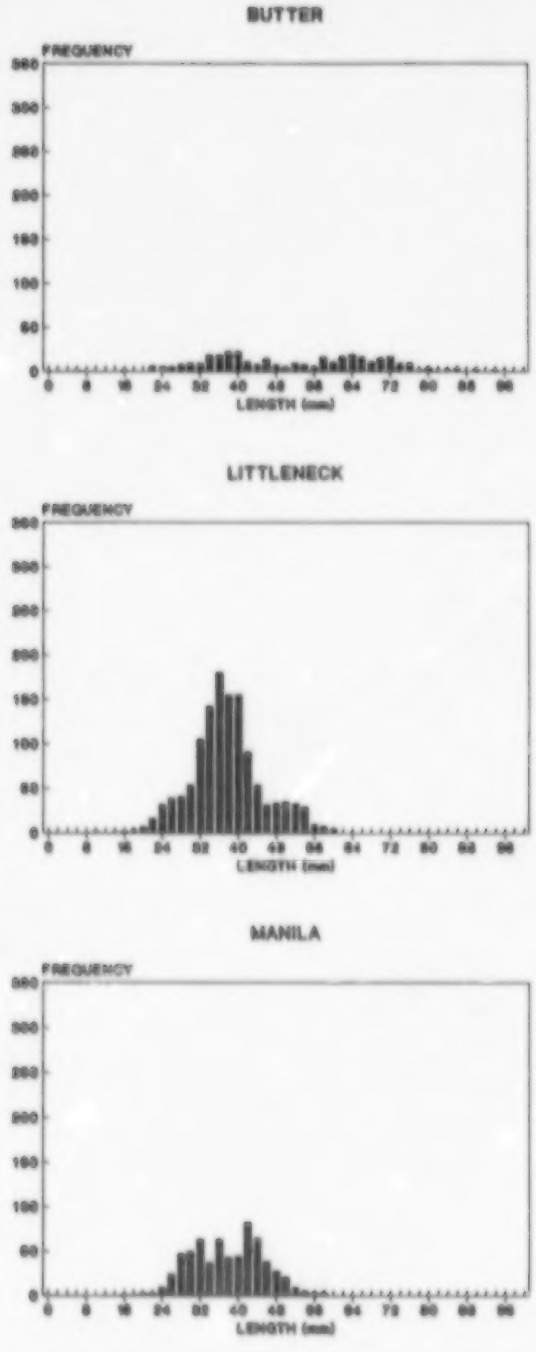

Figure 38. Length frequency distributions of butter, littleneck and manila clams at Mary Basin - Site 1, August 1984.

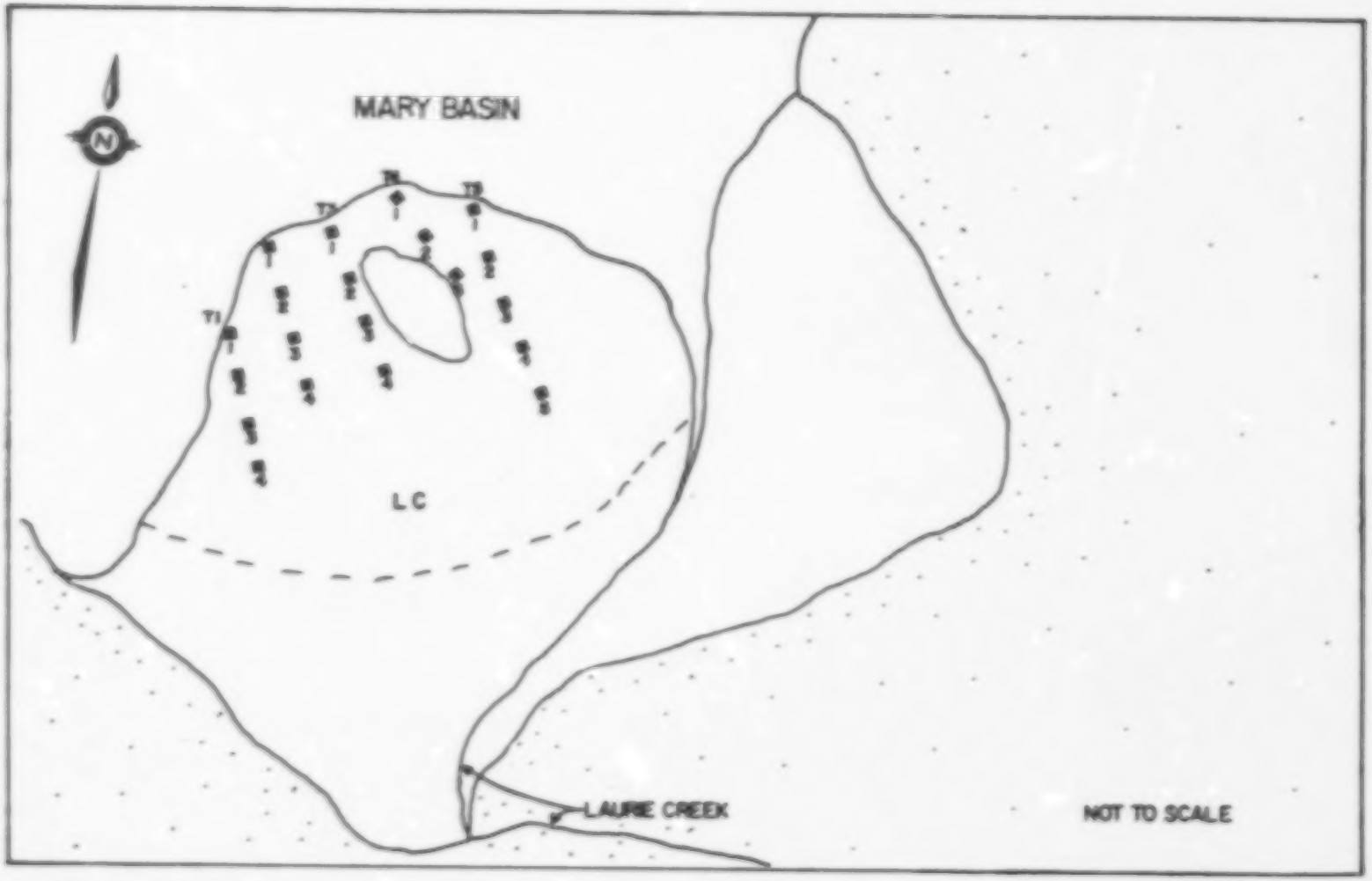

Figure 39. Location of sample plots at Laurie Creek, August 1984.

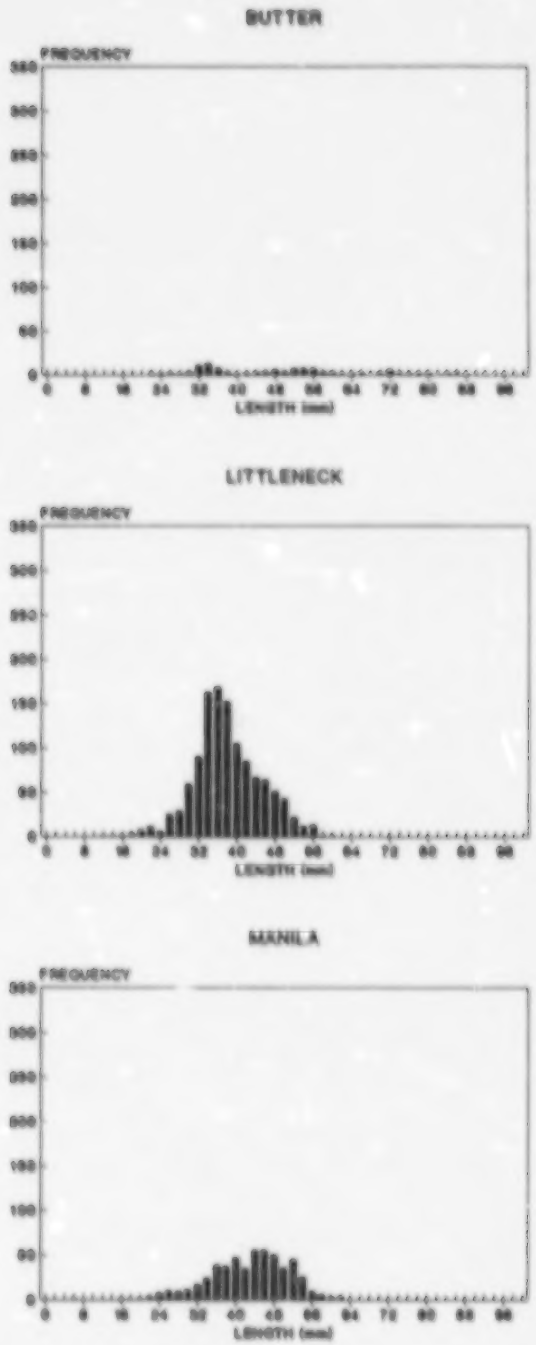

Figure 40. Length frequency distributions of butter, littleneck and manila clams at Laurie Creek, August 1984.

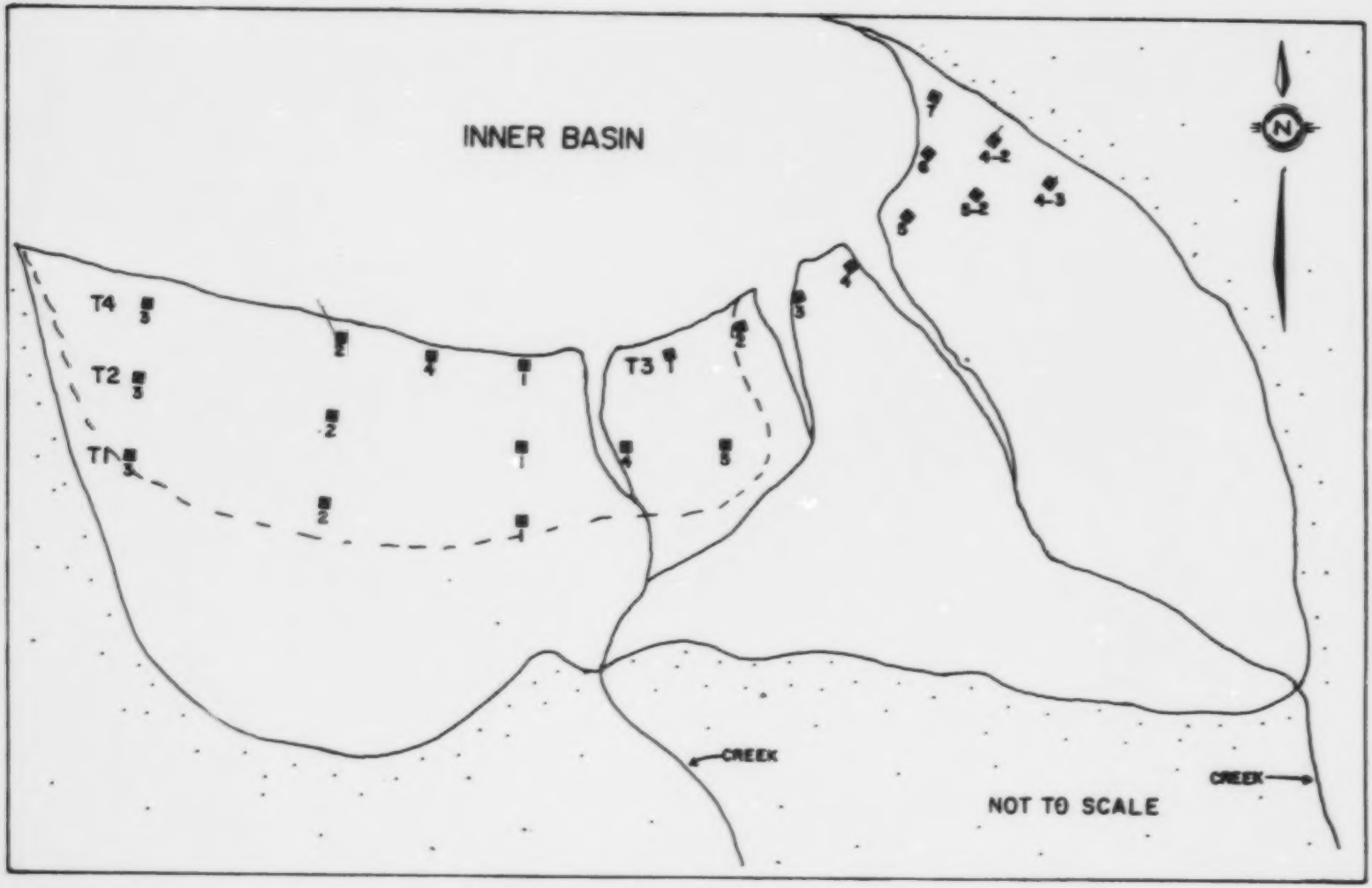

Figure 41. Location of sample plots at Inner Basin, August 1984.

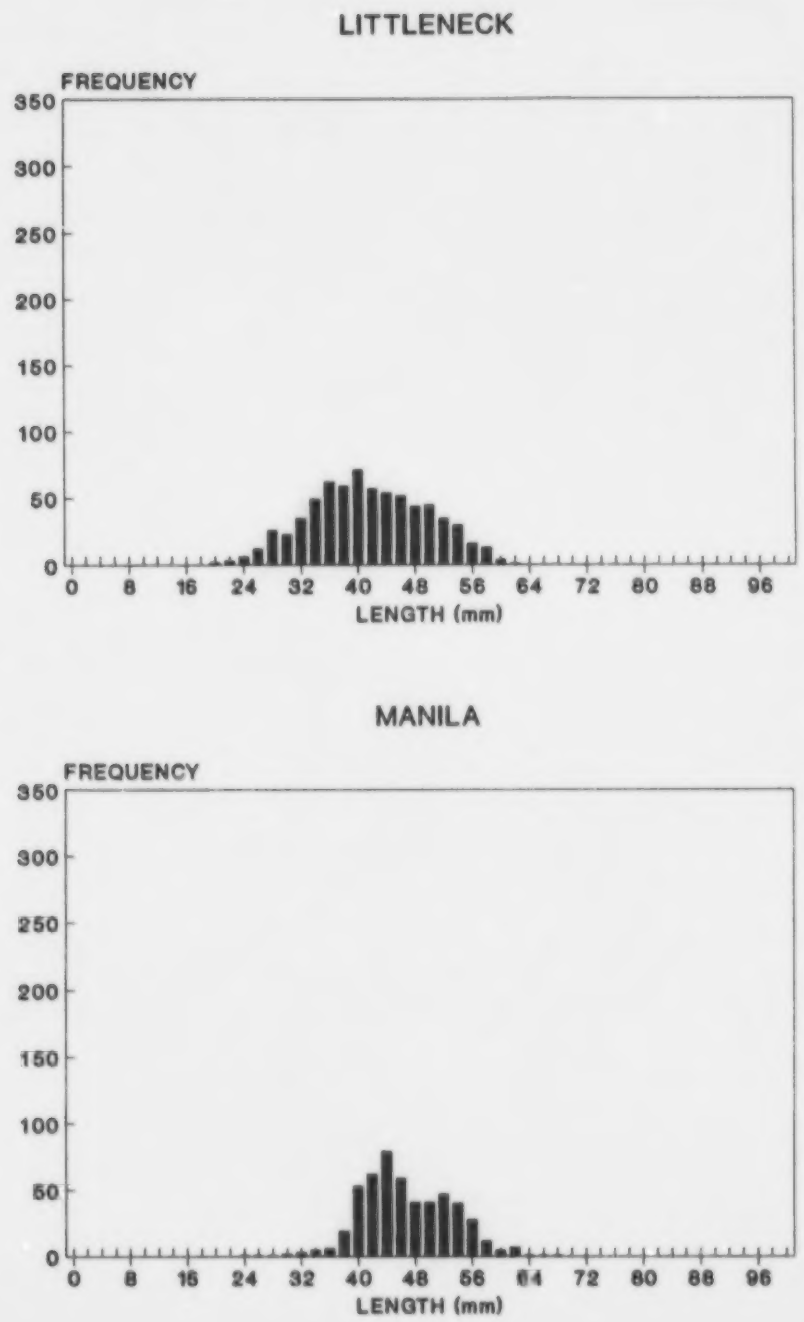

Figure 42. Length frequency distributions of littleneck and manila clams at Inner Basin, August 1984.

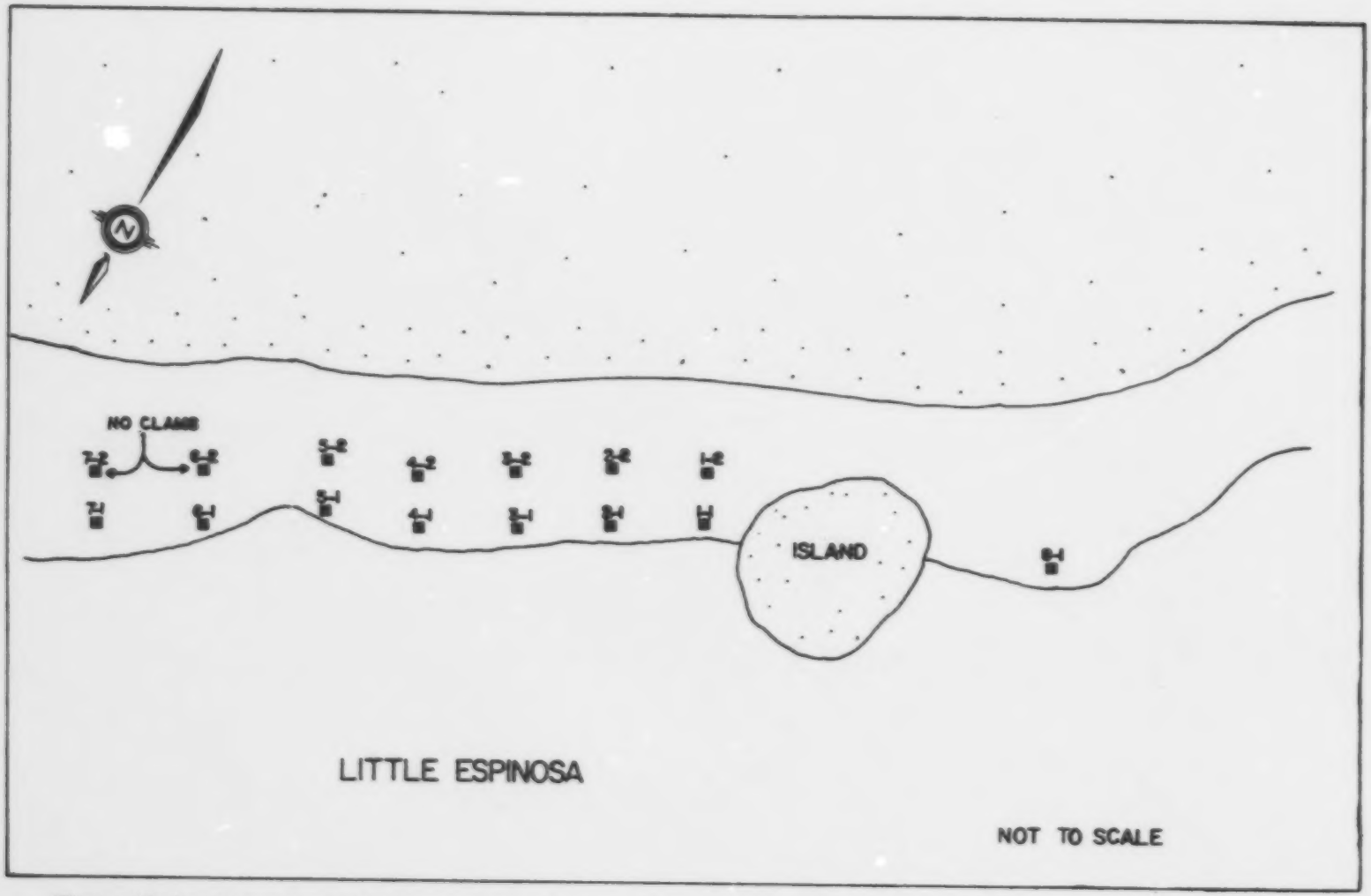

Figure 43. Location of sample plots at Little Espinosa Site 1, August 1984.

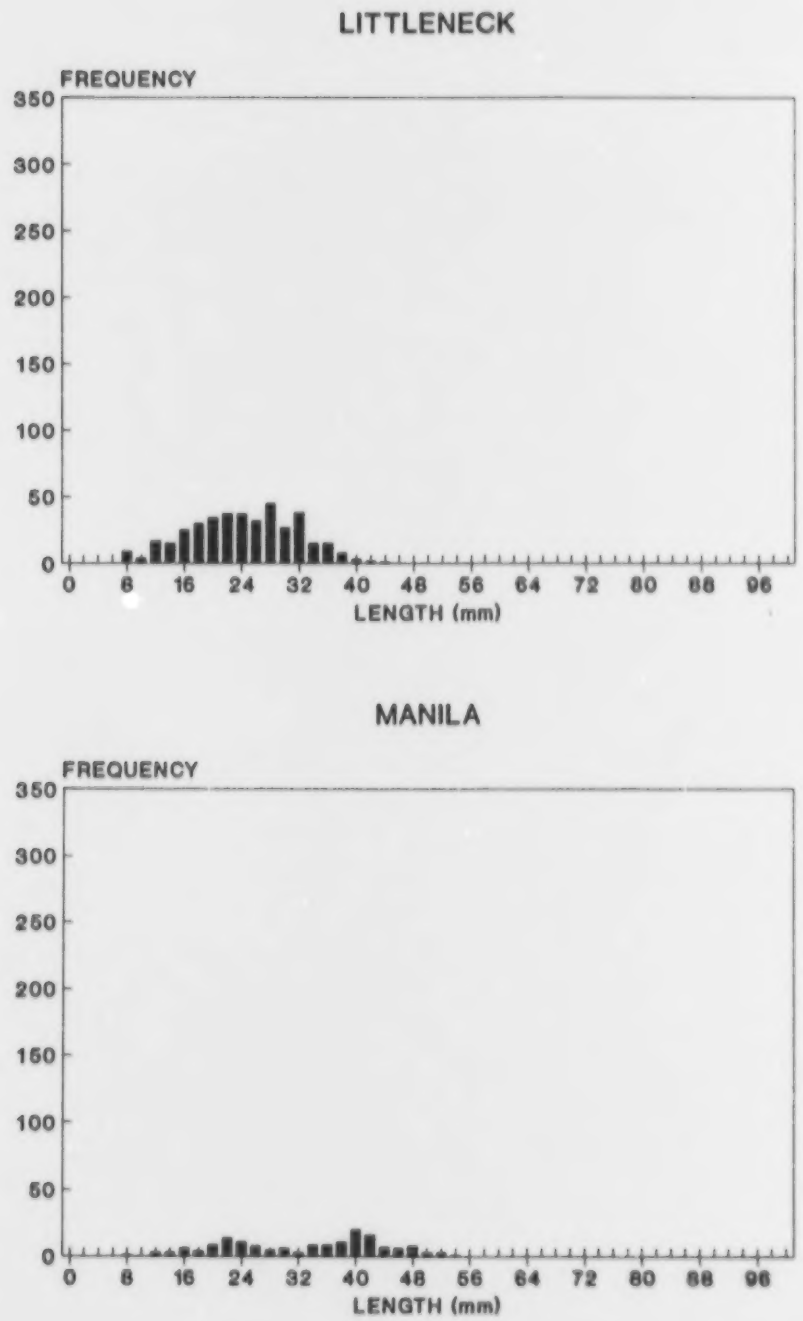

Figure 44. Length frequency distributions of littleneck and manila clams at Little Espinosa Site 1, August 1984.

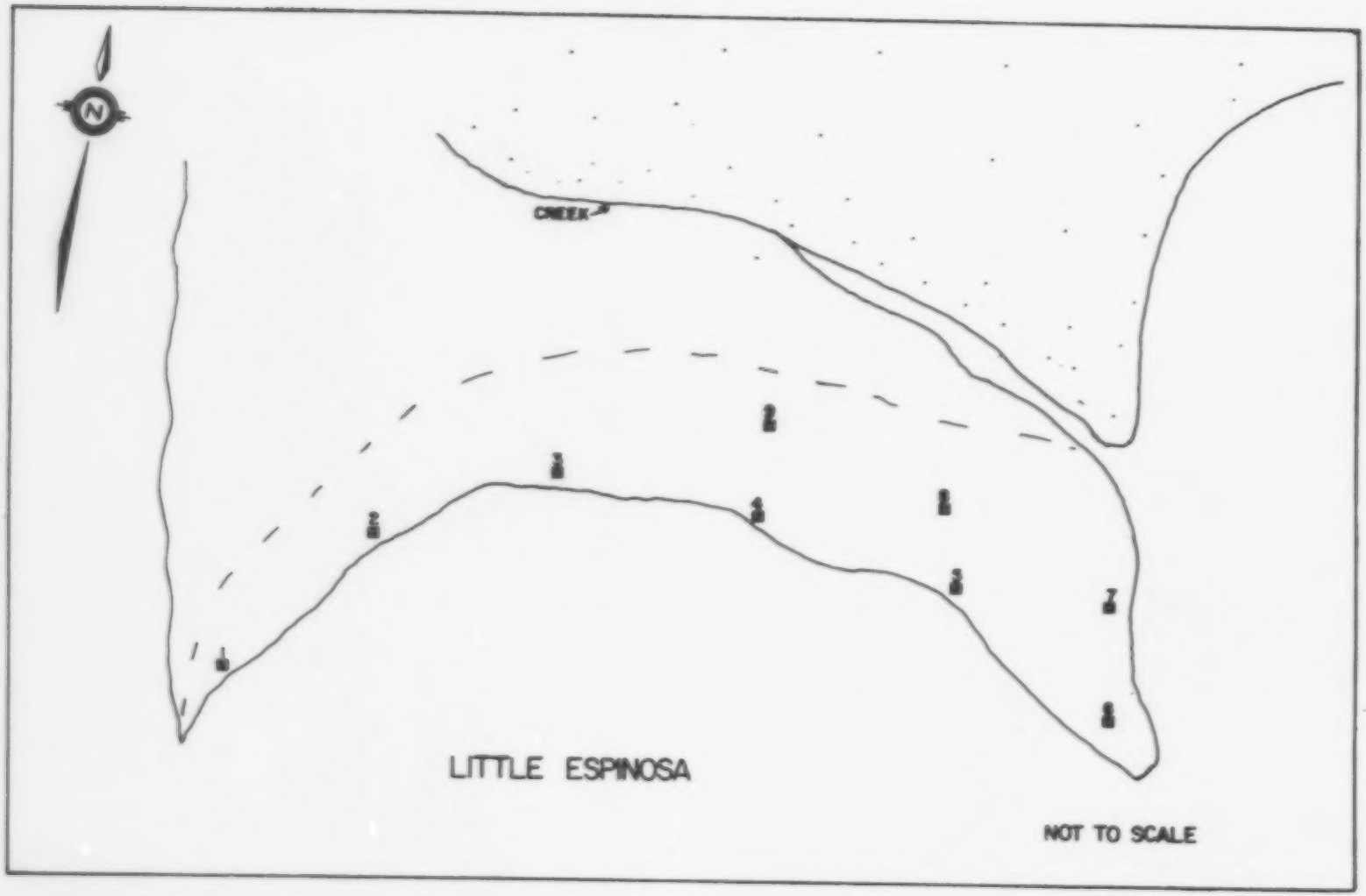

Figure 45. Location of sample plots at Little Espinosa Site 2, August 1984.

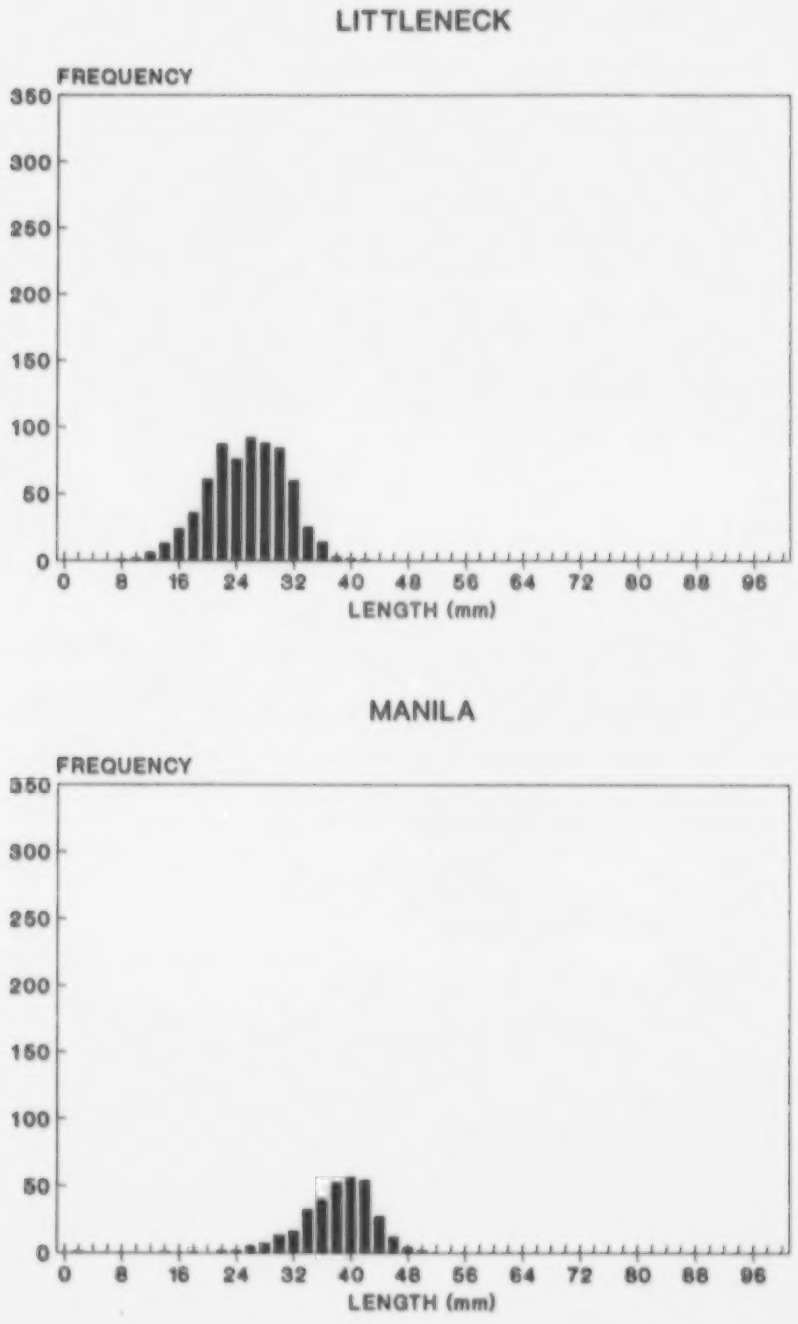

Figure 46. Length frequency distributions of littleneck and manila clams at Little Espinosa Site 2, August 1984.

Figure 47. Mean densities (clams m^{-2}) of littleneck and manila clams at Atleo River and Whiskey Jenny, 1980 to 1987.

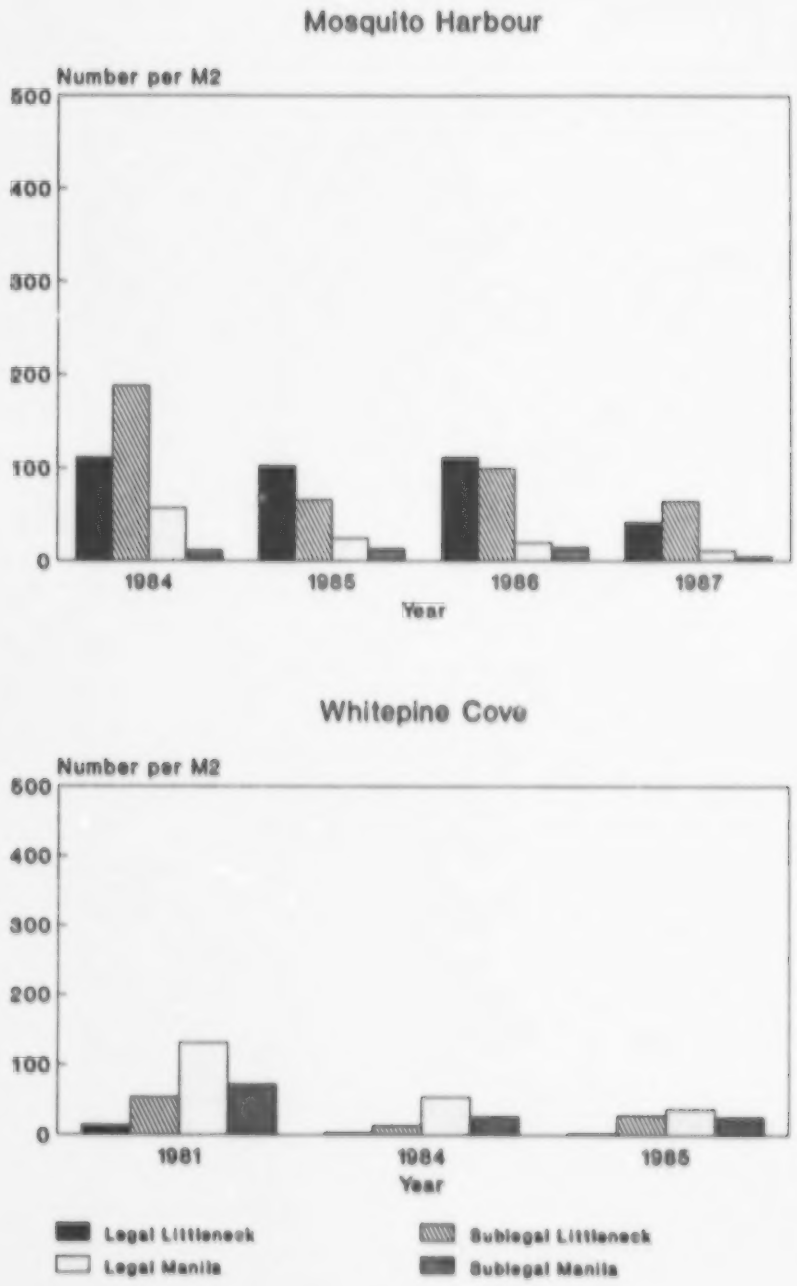

Figure 48. Mean densities (clams m^{-2}) of littleneck and manila clams at Mosquito Harbour, 1984 to 1987, and Whitepine Cove 1981 to 1985.

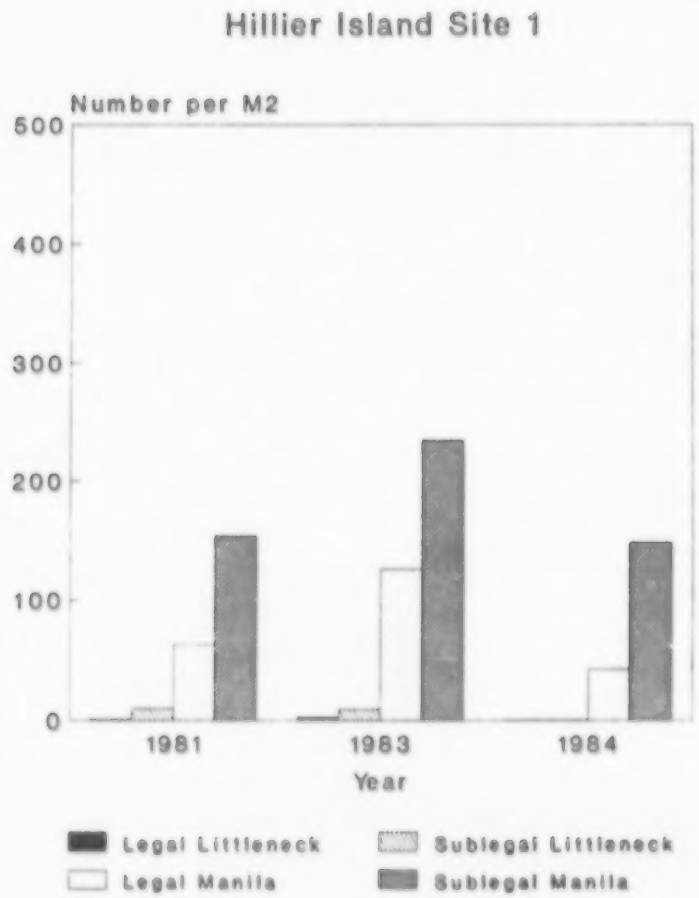

Figure 49. Mean densities (clams m^{-2}) of littleneck and manila clams at Hillier Island; 1981, 1983 and 1984.

APPENDIX 1 - Survey Results Areas 23 to 25, 1981 to 1987

A. Area 23 - Barkley Sound

1. Hillier Island, Toquart Bay

Three small clam beaches on Hillier Island, sites 1, 2, and 3 (Fig. 5), were sampled during November 1981, February 1983 and February 1984. The largest beach, site 1, appeared to have been most heavily harvested and was sampled during each of these years.

Between 1981 and 1983 during the commercial clam closure in Area 23, there was a significant ($p < 0.05$) increase in density of both legal and sublegal sized manila clams at site 1 on Hillier Island. The mean densities of legal and sublegal sized manila clams increased from 62.8 per m^2 to 126.0 per m^2 and from 154.0 per m^2 to 234.0 per m^2 between 1981 and 1983 respectively. In February 1984, following a short six week commercial clam opening in Area 23 during 1983, we observed a significant decline ($p < 0.05$) in the density of both legal and sublegal sized manila clams from the 1983 estimates at this site to, 42.3 and 148.0 per m^2 respectively (Table 9).

Littleneck clams, although they occurred at much lower densities than did manila clams at Hillier Island, showed similar changes in abundance between 1981 and 1984 at site 1. Densities of legal sized littlenecks at this site were 1.0, 2.4 and 0.5 per m^2 and densities of sublegal sized littlenecks were 9.8, 9.2 and 0.5 per m^2 in 1981, 1983 and 1984 respectively (Table 9).

Sites 2 and 3 (Fig. 5) were surveyed only in 1983. The combined harvestable area of these beaches was only 0.5 ha. The densities of legal and sublegal sized littleneck and manila clams sampled at these sites are described in table 9.

Length frequency distributions of manila and littleneck clams from the surveys at Hillier Island between 1981 and 1984 are shown in Figs. 6 to 8. Mean length of manila clams at site 1 was constant during this period; 34.0 mm in 1981, 34.3 mm in 1983 and 35.0 mm in 1984.

2. Pinkerton Islands, Sechart Channel

The Pinkerton Islands are a small group of islands in Sechart Channel supporting several small clam beaches varying in size from 0.32 ha to 1.25 ha. Three beaches were surveyed in this area during February 1983. Mean densities of legal and sublegal sized manila clams were 39.4 and 38.6 per m^2 respectively and of legal and sublegal sized littleneck clams were 16.0 and 14.2 per m^2 respectively. The densities of legal and sublegal sized butter clams at these sites were 2.60 and 4.00 per m^2 respectively (table 9).

Length frequency distributions for each species are shown in Fig. 9. Mean lengths were 38.4 mm, 33.9 mm and 59.4 mm for native littleneck, manila and butter clams respectively.

3. Lucky Creek, Pipestem Inlet

This site at the entrance to Pipestem Inlet had only about 0.5 ha of harvestable clam bearing area. Manila clams were the only species observed in the six 0.25 m^2 plots sampled at this site during February 1983. Mean densities of legal and sublegal sized manila clams at this site were 25.3 and 463.0 per m^2 respectively (table 9).

The length frequency distribution of manila clams from this site is shown in Fig. 9. There was a major peak at about 20 mm which likely represents successful recruitment of this beach in 1981. Only 5.2% of the clams sampled, were legal size; mean length was 22.0 mm.

4. Cataract Creek, Pipestem Inlet

Only manila clams occurred in the nine 0.25 m^2 plots sampled from this 0.20 ha beach during February 1983. Mean densities of legal and sublegal sized manila clams were 33.8 and 101.0 per m^2 respectively (table 9). The length frequency distribution is shown in Fig. 10; mean length was 33.4 mm.

5. Bazette Island, Pipestem Inlet

This 0.1 ha site was sampled during February 1983 and was the smallest commercial beach sampled during this survey. Manila clams were far more abundant than native littlenecks in all six 0.25 m^2 plots sampled at this site. Mean densities of legal and sublegal sized manila clams were 189.0 and 69.3 per m^2 and of legal and sublegal sized littlenecks 0.67 and 4.67 per m^2 respectively (table 9). The length frequency distribution of manila clams sampled at this site is shown in Fig. 10.

6. Useless Inlet, Imperial Eagle Channel

Three small clam beaches, varying in size from 0.25 to 1.2 ha, are located in Useless Inlet. Clams were sampled from nine 0.25 m^2 plots on the largest of these beaches during February 1983. Mean densities of legal and sublegal sized manila clams were 127.0 and 50.7 per m^2 respectively and of legal and sublegal sized littleneck clams 5.8 and 42.2 per m^2 respectively. No legal butter clams occurred in any of the sample plots, however, density of sublegal sized butter clams was 4.9 per m^2 (table 9).

The length frequency distributions for manila and littleneck clams are shown in Fig. 11. Mean lengths of manila and littleneck clams sampled at this site were 41.0 mm and 30.2 mm respectively.

7. Stopper Islands, Toquart Bay

In February 1983, we sampled clams from eight 0.25 m^2 plots on a small 0.20 ha beach on the southwest side of the passage between the two Stopper Islands. Manila clams were far more abundant than either native littleneck or butter clams at this site. Mean densities of legal and sublegal sized manila clams were 58.5 and 223.0 per m^2 respectively, for littleneck clams 4.5 and 5.5 per m^2 respectively and for butter clams 0.5 and 1.2 per m^2 respectively (table 9).

8. Harris Point, Toquart Bay

The clam beach at Harris Point had an estimated harvestable area of only 0.5 ha. Manila clams were most abundant in all six 0.25 m^2 plots sampled from this site during February 1983. Mean densities of legal and sublegal sized manila clams were 91.3 and 191.0 per m^2 respectively littlenecks occurred in only some of the sample plots; mean densities of legal and sublegal sized littlenecks were only 4.0 and 4.0 per m^2 respectively.

9. Vernon Bay, Imperial Eagle Channel

Three small beaches were surveyed in Vernon Bay during February 1983. Total estimated combined harvestable area was only 1.0 ha. Manila clams were most abundant in the fourteen 0.25 m^2 sampled at this site. Mean densities of legal and sublegal sized manila clams were 125.7 and 63.7 per m^2 respectively. Mean densities of legal and sublegal sized littlenecks were only 1.14 and 63.1 per m^2 respectively (table 9).

B.AREA 24 - CLAYOQUOT SOUND

1. Atleo River, Millar Channel

Atleo River is one of the major clam producing beaches in Area 24, having an estimated harvestable area of about 3.0 ha.

The clam beaches at Atleo River were first surveyed during August 1980 by Bourne and Farlinger (1982). Following their methods we conducted surveys at Atleo River during the summers of 1983, 1984, 1985, 1986 and 1987. Results are presented in table 11. Fig. 12 illustrates the location of sample plots at this site.

Estimated mean densities of legal and sublegal sized manila clams were: 46.9 and 67.5 per m^2 in 1983; 18.5 and 30.1 per m^2 in 1984; 41.8 and 50.2 per m^2 in 1985; 50.0 and 68.0 per m^2 in 1986 and 2.5 and 9.0 per m^2 in 1987. Mean densities of legal and sublegal sized littlenecks were: 33.5 and 207.5 per m^2 in 1983; 52.7 and 227.0 per m^2 in 1984; 61.9 and 377.1 per m^2 in 1985; 77.3 and 435.6 per m^2 in 1986 and 17.1 and 115.3 in 1987. Mean densities of legal sized butter clams were: 12.4 and 27.7 per m^2 in 1983; 29.2 and 40.1 per m^2

in 1984; 20.7 and 38.5 per m^2 in 1985; 39.8 and 18.6 per m^2 in 1986 and 30.8 and 26.8 per m^2 in 1987 (table 11).

Length frequency distributions for all species from all surveys conducted between 1983 and 1987 at Atleo River are shown in Figs. 13 to 17. The percentage of legal sized manila clams showed little change from 1983 to 1986 and ranged from 38.1% to 45.5%. The results from the 1987 survey, however, showed a decline in the percent of legal sized manila clams to only 21.7% (table 11).

The percent of legal sized littleneck clams was relatively constant during the course of this study and ranged from a high of 18.8% in 1983 to a low of 12.9% in 1987. These estimates were all considerably lower than the 1980 estimate of 38.0% of Bourne and Farlinger (1982). The percent of legal sized butter clams ranged between 18.6% to 42.1% between 1983 and 1987. Only 26.8% of the butter clams sampled in 1987 were legal size (table 11).

2. Whiskey Jenny, Shelter Inlet

Whiskey Jenny is a long narrow beach of coarse gravel substrate with approximately 4.3 ha of harvestable clam bearing area. Clam populations were concentrated in an area up to 600 m west of the large rock at the most easterly end of the beach (Fig. 18). Although more remote than many other clam beaches in Area 24, Whiskey Jenny has produced a significant portion of the reported clam landings from this area (Bourne and Farlinger, 1982). Whiskey Jenny was closed to commercial harvesting of littleneck and manila clams from November 1, 1984 to April 30, 1987 for conservation concerns (Appendix 3).

Four surveys were carried out at Whiskey Jenny between 1983 and 1987 to estimate the abundance of harvestable clam. Results of these surveys are detailed in table 11. Mean densities of legal and sublegal sized manila clams were: 1.7 and 1.4 per m^2 in 1983; 1.0 and 0.4 per m^2 in 1984; and 3.3 and 3.8 per m^2 in 1985. No manila clams occurred in any of the sample plots at this site in 1987. Mean densities of legal and sublegal sized littleneck clams were: 35.8 and 58.0 per m^2 in 1983; 37.3 and 28.1 per m^2 in 1984; 23.5 and 57.0 per m^2 in 1985 and 15.4 and 43.1 per m^2 in 1987. Mean densities of legal and sublegal sized butter clams were: 17.5 and 34.6 per m^2 in 1983; 9.9 and 14.0 per m^2 in 1984; 19.3 and 37.8 per m^2 in 1985 and 6.6 and 11.5 per m^2 in 1987.

Length frequency distributions for littleneck and butter clams from Whiskey Jenny for 1983, 1984, 1985 and 1987 are shown in Figs. 19 to 22. Manila clam densities were too low to compare length frequencies. Mean lengths estimated from surveys at Whiskey Jenny in 1983, 1984, 1985 and 1987 were: 20.1 mm, 35.9 mm, 29.8 mm and 29.3 mm for littlenecks and 50.4 mm, 51.1 mm, 52.4 mm and 52.3 mm for butter clams respectively. Manila clam mean lengths were 37.4 mm in 1983 and 36.7 mm in 1984. Only 11 manila clams occurred in the sample plots in 1985.

3. Whitepine Cove, Herbert Inlet

Whitepine Cove is a well known commercial clam beach located in Herbert Inlet with an estimated harvestable area of approximately 3.0 ha. This beach supported mainly native littleneck clams but also had significant populations of manila. Whitepine Cove was closed to commercial harvesting of littleneck and manila clams from January 1, 1981 to December 31, 1987 as a result of declining clam stocks (Appendix 3).

Surveys were carried out in 1981, 1984 and 1985 at Whitepine Cove . Fig. 23 illustrates the location of the sample plots spaced at 25 metre intervals at this site. Results of these surveys showed a significant ($p < 0.05$) decline in estimated stock for all three commercial species between 1981 and 1984 but no significant ($p < 0.05$) change between 1984 and 1985. Estimated mean densities of legal and sublegal sized littlenecks were: 14.1 and 53.4 per m^2 in 1981; 3.1 and 12.6 per m^2 in 1984 and 2.1 and 27.6 per m^2 in 1985. Mean densities of legal and sublegal sized manila clams were: 131.6 and 71.8 per m^2 in 1981; 54.0 and 26.1 per m^2 in 1984 and 37.3 and 25.1 per m^2 in 1985. Mean densities of legal and sublegal sized butter clams were: 1.4 and 12.2 per m^2 in 1981; 0.5 and 1.0 per m^2 in 1984 and 0.4 and 2.9 per m^2 in 1985 (table 11).

Length frequency distributions of manila and littleneck clams sampled from Whitepine Cove in 1981, 1984 and 1985 are shown in Figs. 24 to 26.

Although their numbers declined significantly between 1981 and 1984, the percentage of legal sized manila clams remained relatively constant during the period of this study; 64.7% in 1981, 67.4% in 1984 and 59.8% in 1985 (table 11). Mean lengths of manila clams were 40.1 mm in 1984, 39.7 mm in 1984 and 37.6 mm in 1985. Littlenecks clams were mostly sublegal sized at Whitepine Cove, however, the proportion of legal sized littlenecks declined steadily during the time of these surveys from 20.9% in 1981 to 12.6% in 1984 to only 7.2% in 1985 (table 11). Mean lengths of littleneck clams were 32.8 mm in 1981, 30.9 mm in 1984 and 29.2 mm in 1985.

4. Warn Bay, Fortune Channel

Several small commercial clam beaches are located in Warn Bay. The largest of these beaches was sampled in 1981 and again in 1984. The total estimated harvestable area at this site was 1.2 ha. Warn Bay was closed to commercial harvesting of littleneck and manila clams for the periods of November 1, 1981 to April 30, 1983 and January 1 to April 30, 1987 (Appendix 3). Fig. 27 illustrates the clam bearing area and the location of the sample plots, spaced 25 m apart at this site.

Results of the 1981 and 1984 surveys at Warn Bay are shown in Table 11. Few manila clams occurred in any of the plots sampled in 1981 but mean densities of legal and sublegal sized manila clams were estimated at 9.8 and 9.4 per m^2 respectively in 1984. Mean densities of legal and sublegal sized littleneck clams were 44.2 and 91.0 per m^2 in 1981 and 53.0 and

97.0 per m^2 respectively in 1984. Mean densities of legal and sublegal sized butter clams were 2.9 and 11.7 per m^2 in 1981 and 8.8 and 30.6 per m^2 in 1984 respectively.

Length frequency distributions from samples taken in 1981 and 1984 are shown in Figs. 28 and 29. In 1981 32.7% of littlenecks and 30.7% of butter clams were legal size ; no manila clams were found at this site in 1981. In 1984 35.5 % of littlenecks, 51.0% of manila and 17% of butter clams were legal sized. Mean lengths were 35.1 mm and 50.7 mm respectively for littleneck and butter clams in 1981. In 1984 mean lengths were 33.0 mm 37.2 mm 50.7 mm for littleneck ,manila and butter clams respectively.

5. Mosquito Harbour, Meares Island

Surveys were carried out at on a small 0.6 ha beach, located at the head of Mosquito Harbour in 1984, 1985, 1986 and 1987. Fig. 30 illustrated the clam bearing area and the location of the sample plots, separated by 25 metres, at this site. Mosquito Harbour was closed to commercial harvesting of littleneck and manila clams for the periods of November 1, 1981 to April 30, 1983 and January 1 to April 30, 1987 (Appendix 3).

Results of all surveys at Mosquito Harbour are shown in table 11. Native littlenecks were most abundant in each survey. Mean densities of legal and sublegal sized littlenecks were: 111.0 and 188.0 per m^2 in 1984; 101.0 and 65.4 per m^2 in 1985; 111.0 and 99.2 per m^2 in 1986 and 41.1 and 63.3 per m^2 in 1987. Mean densities of legal and sublegal sized manila clams were: 56.9 and 11.3 per m^2 in 1984; 25.5 and 13.3 per m^2 in 1985; 19.7 and 14.3 per m^2 in 1986 and 11.1 and 4.8 per m^2 in 1987. Mean densities of legal and sublegal sized butter clams: 0.2 and 9.6 per m^2 in 1984; 1.2 and 6.0 per m^2 in 1985 and 5.9 and 2.5 per m^2 in 1987. No butter clams occurred in any of the sample plots at this site in 1986.

Length frequency distributions from each survey are shown in Figs. 31 to 34. The proportion of legal sized littleneck clams increased from 37.1% in 1984 to 60.9% in 1985 but decreased to 39.4% in 1987. Mean shell lengths of littleneck clams were 35.2 mm, 34.7 mm, 36.1 mm and 35.1 mm for 1984 through 1987 respectively. Most manila clams were legal size; 83.4% in 1984, 64.8% in 1985, 57.9% in 1986 and 69.9% in 1987. Mean shell lengths of manila clams sampled at this site were; 46.0 mm, 39.3 mm, 44.4 mm and 41.9 mm for 1984 through 1987 respectively. Only 2.25% of the butter clam sampled in 1984 were legal size, 16.3 % in 1985 and 2.50% in 1987. Mean shell lengths of butter clams were; 52.2 mm, 52.5 mm and 48.4 mm for 1984, 1985 and 1987 respectively.

6. Sulphur Passage, Obstruction Island

In July 1985 the largest of a number of small clam beaches located on the east side of Sulphur Passage was sampled. Total estimated harvestable area of this beach was 1.6 ha. Clams were sampled from nine 0.50 m^2 plots distributed evenly over most of the clam bearing area (Fig. 35). Six clam culture plots had been set up on this beach, hence those areas were excluded from our samples.

Estimated mean densities of legal and sublegal sized littlenecks were: 40.4 and 251.8 per m^2; of legal and sublegal sized manila clams 65.1 and 28.2 per m^2 and of legal and sublegal sized butter clams 1.1 and 6.0 per m^2 respectively (table 11).

Length frequency distributions for littleneck, manila and butter clams sampled from this site are shown in Fig. 36. Only 13.8% of the littlenecks were legal size; mean shell length was 31.1 mm. Most manilas (69.8%) were legal size; mean shell length was 39.0 mm. Butter clams were 40.0% legal size and mean shell length was 57.7 mm.

C. AREA 25 - ESPERANZA INLET

1. Mary Basin - Site 1

This beach is located on the north-east side of Mary Basin and was the largest site surveyed during this study. Total harvestable area was estimated at 8.0 ha.

Adkins et al. (1983) estimated commercial clam abundance on this beach in both 1981 and 1982. This site was surveyed again during August 1984 following the methods of Adkins et. al. (1983). Fig. 37 illustrates the location of the sample plots.

Results from the 1984 survey showed a significant increase in the estimated densities of legal and sublegal sized manila clams at this site in Mary Basin over the 1982 estimates of Adkins et al. (1983). Mean densities of legal and sublegal sized manila clams were 18.1 and 24.8 per m^2 respectively in 1984 compared to the 1982 estimates of only 4.0 and 1.72 per m^2 respectively (Adkins et al. 1983). No significant change in either the littleneck or butter clam densities were evident at this site in 1984 over the 1982 estimates. Mean densities of legal and sublegal sized littlenecks were 63.5 and 80.5 per m^2 and of legal and sublegal sized butter clams 4.2 and 13.1 per m^2 respectively. Adkins et al. (1983) estimated mean densities of legal and sublegal sized littlenecks at 63.7 and 76.4 per m^2 and of legal and sublegal sized butter clams at 5.4 and 12.7 per m^2 respectively in 1982 (table 13).

Length frequency distributions for each species sampled at Mary Basin during 1984 are shown in Fig. 38. There was evidence of some low levels of recent recruitment to all three species sampled at this site. Littlenecks were 44.4% legal size; mean length was 36.3 mm. Manila clams were 42.2 % legal size. Butter clams were only 26.5% legal size; mean length was 49.8 mm.

2. Laurie Creek, Mary Basin

This beach is located at the mouth of Laurie Creek, on the south-east side of Mary Basin; total estimated harvestable area was about 5.0 ha. Adkins et al. (1983) estimated commercial clam densities at Laurie Creek in 1981 and 1982. This site was surveyed again in 1984

following the methods of Adkins et al. (1983). Fig. 39 illustrates the location of the sample plots on this beach.

No significant ($p<0.05$) change in abundance of any commercial species was noted in 1984 over the 1982 estimates of Adkins et al. (1983). Estimates mean densities of legal and sublegal sized littlenecks were: 50.3 and 80.2 per m^2 ; legal and sublegal sized manila clams were; 29.4 and 14.3 per m^2 and legal and sublegal sized butter clams were 1.7 and 9.5 per m^2 respectively (table 13).

Length frequency distributions for each species from the 1984 survey at Laurie Creek are shown in Fig 40. Littlenecks were 38.4% legal size; mean length was 36.1 mm. Manilas were 67.3% legal size; mean length was 41.3 mm and butter clams 15.2% legal size; mean length was 45.6 mm.

3. Inner Basin

The only commercial clam beach in Inner Basin is located at the head of the basin. Estimated harvestable area was about 5.0 ha. The main concentrations of clams were on the southern end of this beach. Fig.41 illustrates the clam bearing area and the location of the plots sampled in 1984.

Adkins et al. (1983) surveyed the beach at the head of Inner Basin in 1981 and 1982 to determine the effects of hydraulic clam harvesting on clam stocks at this site. In 1984 we found a significant ($p<0.05$) decline in the abundance of legal and sublegal sized littleneck clams and in the abundance of legal sized manila clams from the 1982 estimates at this site. The densities of sublegal sized manila clams and of legal and sublegal sized butter clams were similar to the 1982 estimates of Adkins et al. (1983). Results of these surveys are shown in table 13.

From plots sampled in 1984 in Inner Basin mean densities of legal and sublegal sized littlenecks were: 38.7 and 29.2 per m^2; manilas clams were: 42.9 and 55.6 per m^2 and butter clams were 0.1 and 0.2 per m^2 respectively.

Length frequency distributions for littleneck and manila clams from the 1984 survey at Inner Basin are shown in Fig. 42. Littleneck clams were 57.0% legal size; mean length was 39.8 mm. Manila clams were 88.5% legal size; mean length was 45.1 mm.

4. Little Espinosa Inlet

Two commercial clam beaches, both close to road access, were surveyed in Little Espinosa Inlet during 1984 as a result of concerns of over harvesting in this area during the winter of 1983 and spring of 1984.

Little Espinosa (site 1), located at the entrance to Little Espinosa Inlet, offered only marginal clam habitat. Substrate was muddy and clam density was generally low. Native

littleneck and manila clams occurred in similar proportions while butter clams showed as only a trace in these samples. Total estimated harvestable area of this beach was approximately 1.5 ha. There was little or no evidence of recent commercial clam harvesting at this site.

Clams were sampled from fifteen 0.5 m plots located along the length of the beach (Fig. 43). Mean densities of legal and sublegal sized littlenecks were: 50.9 and 55.2 per m^2 respectively. Mean densities of legal and sublegal sized manila clams were: 47.9 and 17.2 per m^2 respectively and mean densities of legal and sublegal sized butter clams were 0.8 and 1.3 per m^2 respectively (table 13).

Length frequency distributions for each species are shown in Fig. 44. Forty-eight percent of the littlenecks were legal size; mean shell length was only 22.8 mm. Manilas were 38.2% legal size; mean shell length was 31.5 mm. Butter clams were 37.6% legal and mean shell length was 15.9 mm.

Little Espinosa (site 2), located at the head of Little Espinosa Inlet had much more productive clam habitat than did site 1. Substrate was fine gravel with a moderate amount of organic fines. There was evidence of a recent fishery at this site; holes and trenches resulting from commercial hand digging.

Clams were sampled from a series of eight 0.5 m plots placed in a grid pattern over the clam bearing portion of the beach (Fig. 45). Estimated mean densities of legal and sublegal sized littlenecks were: 1.50 and 1.36 per m^2 and mean densities of legal and sublegal sized manila clams were: 52.5 and 70.5 per m^2 respectively. for manilas. No legal size butter clams occurred in any of the samples; density of sublegal sized butter clams was 4.50 per m^2 (table 13).

Length frequency distributions of manila and littleneck clams are shown in Fig. 46. Both species showed some evidence of recent recruitment. Only 0.5 % of the littlenecks sampled were legal size; mean shell length was 23.9 mm. Manila clams were 45.8% legal size; mean shell length of 36.4 mm.

APPENDIX 2 - Commercial Clam Beach Closures in Area 23 1980 to 1987

1. 1980 - all beaches closed due to a low abundance of clams.

2. 1981 - all beaches closed due to a low abundance of clams.

3. 1982 - all beaches closed due to a low abundance of clams.

4. 1983 - all clam beaches closed January 1 to March 13 and May 1 to December 31.

5. 1984 - all beaches closed January 1 to November 1.

6. 1985 - all beaches closed January 1 to November 1.

7. 1986 - all beaches closed due to high levels of PSP.

8. 1987 - all beaches closed January 1 to November 1.

APPENDIX 3 - Commercial Clam Beach Closures in Area 24 1980 to 1987

1. 1980 - permits were issued for commercial harvest of clams
   - no public notices issued opening any area
   - public notice issued closing area 14 to clam harvesting because of PSP.

2. 1981 - April 15 closed for PSP
   - November 1 to December 31 open for harvesting of all species in all areas except for:
     a. Meares Island
     b. Foreshore on westerly side of Esowista Peninsula
     c. Foreshore fronting parks and Indian Reserves
     d. Warn Bay

3. 1982 - January 1 to April 30 open except for:
     a. Meares Island
     b. Foreshore on westerly side of Esowista Peninsula
     c. Foreshore fronting parks and Indian Reserves
     d. Warn Bay

- November 1 to December 31 littleneck and manila clams open in all areas except for:
  a. Subareas 24-7, 24-9 and 24-10
  b. All foreshore of Meares Island
  c. All foreshore fronting parks and Indian Reserves

4. 1983 - January 1 to April 30 littleneck and manila clams open in all areas except for:
  a. Subareas 24-7, 24-9 and 24-10
  b. All foreshore of Meares island
  c. All foreshore fronting parks and Indian Reserves

- November 18 to December 31 littleneck and manila clams open in all areas except for:
  a. All foreshore fronting parks and Indian Reserves

5. 1984 - February 27 to April 30 littleneck and manila clams open in all areas except for:
  a. All foreshore fronting parks and Indian Reserves

- November 1 to December 31 littleneck and manila clams open in all areas except for:
  a. All foreshore fronting parks and Indian Reserves
  b. Whiskey Jenny and Little Whitepine Beach

6. 1985 - January 1 to April 30 littleneck and manila clams open in all areas except for:
  a. All foreshore fronting parks and Indian Reserves
  b. Whiskey Jenny, Little Whitepine Cove, Whitepine Cove And Atleo River

- November 1 to December 31 littleneck and manila clams open in all areas except for:
  a. All foreshore fronting parks
  b. Whiskey Jenny, Little Whitepine Cove and Whitepine Cove

7. 1986 - January 1 to January 22 area 24 closed to commercial clam harvest for all species

- January 22 to April 30 littleneck and manila clams open in all areas except for:
  a. Subareas 24-10 and 24-14
  b. Foreshore fronting parks and Indian Reserves
  c. Whiskey Jenny,Little Whitepine Cove, Whitepine Cove and Atleo River

- November 1 to December 31 littleneck and manila clams open in all areas except for:
  a. Foreshore fronting parks and Indian Reserves
  b. Whiskey Jenny, Little Whitepine Cove and Whitepine cove

8. 1987 - January 1 to April 30 littleneck and manila clams open in all areas except for:

a. Subarea 24-10
b. Foreshore fronting parks and Indian Reserves
c. Whiskey Jenny, Little Whitepine Cove and Whitepine Cove

- November 1 to December littleneck and manila clams open in all areas except for:
  a. Foreshore fronting parks and Indian Reserves
  b. Whitepine Cove